A SPECIALIZED MAGAZINE FOR MEDICAL ENTRANCE AND 10+2 EXAMS.

COMPETITION SCIENCE VISION

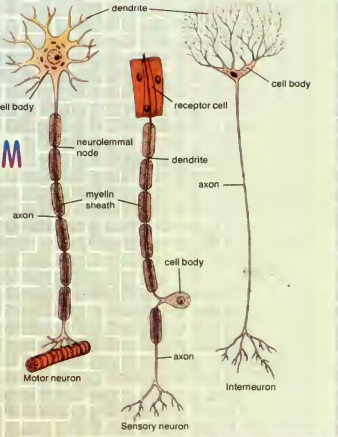
FEBRUARY 1999 PRICE Rs. 30/-

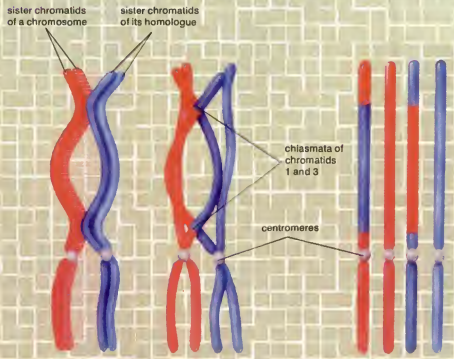
Competition Science Vision is a very good magazine. It is very useful for those preparing for medical competition examinations.

—Ms. Kusum Kumari

Third Topper and First position holder in Girls in B.C.E.C.E. '98

NERVOUS SYSTEM





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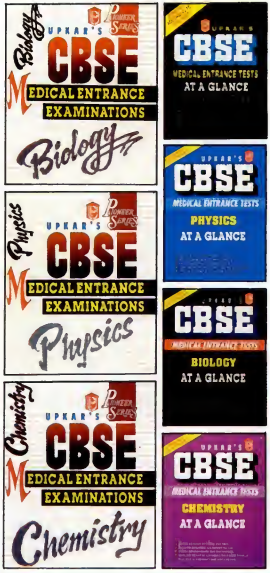

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February 1999
Year–1 Issue–12

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In This Issue

COMPETITION SCIENCE VISION

To Our Readers

Dear Readers,

We are feeling immensely delighted in presenting to you the February issue of your favourite and our prize magazine 'Competition Science Vision' which has come to be recognised country-wide as best educator and motivator for medical aspirants. It will be no exaggeration if we claim that no other science magazine teaches them as we do. CSV keeps you in touch with future and keeps you ahead always. It is a magazine that cares to plan your career.

Each issue of CSV is worth a fortune. It is for you to discover it. Do it right now so that you may not repent later and say 'I should have' ! In order to excel in PMT, you need to acquire the attitude of a winner–deeply committed, highly competitive and completely unflappable. You should be aware of the disturbingly high percentage of those who are eliminated. The level of preparedness accordingly is also unexpectedly very high. CSV is designed to help you achieve your goal. Read CSV for your better tomorrow. We also pray 'God bless you with success in the new year'.

Wishing you again all success in every walk of life.

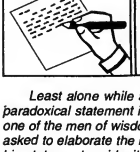
Mahendra Jain
(Editor)

FORTHCOMING COMPETITIVE EXAMS.

1999

B.S.R.B. (Jaipur) Clerical Exam.	(Jan. 17)	B.S.R.B. (Calcutta) Clerical Exam.	(Feb. 28)
Bihar Primary Teacher (Pre.) Exam.	(Jan. 24 & 31)	I.A.F. Airmen Technical Trade Exam.	(Feb.)
UPSC Combined Medical Services Exam.	(Jan.31)	B.P.S.C. Main Exam.	(March 14)
U.P. Combined Lower Subordinate Service (Pre.) Exam.	(Feb. 7)	B.S.R.B. (Baroda) P.O. Exam.	(March 21)
S.B.I. Probationary Officers' Exam.	(Feb. 14)	B.S.R.B. (Dena Bank) P.O. Exam.	(March 21)
Navodaya School Entrance Test	(Feb. 14)	West Bengal (Egg. and Medical) Combined Entrance Exam.	(April 24-25)
Sainik School Entrance Exam.	(Feb. 21)	Combined Defence Services Exam.	(May 2)
B.S.R.B. (Patna) Clerical Exam.	(Feb. 21)	I.I.T. Joint Entrance Exam.	(May 8-9)
B.S.R.B. (Baroda) Agriculture Officers' Exam.	(Feb. 28)	Roorkee Engg. Examination	(May 12-13)

Editorial



Let Loneliness Make You Strong

Least alone while all alone. This paradoxical statement is attributed to one of the men of wisdom, who when asked to elaborate the implications of his statement, said with a smile that you can not be said to be alone when you are busy with something, yourself or your thoughts. Moreover, those persons are always with you whom you remember or with whose thoughts your mind is occupied. When you are engrossed in thoughts, you become unaware of your physical body. In this case the question of your being alone or in some body's company does not arise. The flight of thoughts may take the man round the world, may make him soar high up in the sky or make him comfortable on the waves of the sea. Does such a man miss any body's company or to be practical, does he need someone to talk to ? No third person is required or welcome between the lover and the beloved. To give an illustration, when you are busy with preparations for your examination, you do not want that anyone should come to you and disturb your concentration. Only a disturbed and empty mind needs company because one needs company when he has nothing at hand to be occupied or to be busy with.

While in isolation, persons often try introspection and during this period, the mind stops chattering and wandering. In the words of John Milton, "The mind, when itself and in its own place, can make a heaven of hell." Obviously a man, who has withdrawn himself from the crowd and whose mind is at rest, is in heaven, no matter, whether he cares or tries for it or not.

Every man is made for growth for gaining knowledge and development. His nature is sinned against, when he is doomed to ignorance and left to grope in the darkness of the crowd. These are the words of Cantt, the greatest philosopher of the modern-age, who never, throughout his life, moved out of his village and was always in the company of books. Every man can neither be Cantt, nor can spend life like him but it is proof positive of the fact that one is able to hear the inner voice only when alone. The inner voice is called the Voice of the Silence, which one can hear only when alone or perfectly undisturbed by his surroundings.

Another great thinker, W. E. Canning spent most of his time in library. He liked most the company of books, as to him books were like a multi-purpose friend, guide, helper, teacher, philosopher and what not. For development of faculty of intelligence, the discipline of meditation is prescribed. Contemplation is the next step in this direction, which leads to evolution of consciousness. Isolation provides the proper atmosphere for carrying on and practising this discipline. It was for this reason that the ancient Rishis and Munis were recluse and lived in their Ashrams far away from the din, noise and turmoil of the society. Nature was their company and gods were their friends, who used to interpret in silence, the dictates of the inner voice. Every particle of nature seemed to tell them something new. Day and night, they heard the music of silence. Who would say, they were alone, although they lived alone ?

All great persons like Buddha, Confucius, Moses, Mansoor, Jesus, Mohammed, Newton, Ramanuj, Madam Blavatsky, Vivekanand, Gandhi etc. received their light in isolation. All of them had to be alone for sometime, when their higher selves divulged to them the secrets of life. It is also a fact of life that the toppers at different examinations and competitions used to read and study with doors of their rooms closed and kept aloof from all sorts of disturbance. Their goals of life were their guides and the books their friends. Our friends, young men and women would do well to emulate their examples to get success at the examinations and in life thereafter. Animals as well, to get nourishment from the food and fodder they eat, do chewing the cud in silence. Introspection and self study are done best in isolation. If you do so, you will be surprised to see new vistas of knowledge and new pathways of progress open before you.

In a big crowd, there is hardly anybody to help or to lift the person, who has fallen down. Then how one could say that he is not alone in a big crowd ? It sounds paradoxical but is a fact of life. The crowd saps the vigour of the mind and its possessor is at a discount to make use of it. So, avoid crowd and shun becoming a part of it.

This famous line of Poet Laureate Tagore is very popular and inspiring एकला चलो रे. The words contained in the line have inspired many a person to go alone on the path they thought right. Mahatma Gandhi was also one of those To him the inspiring and assuring words contained in this piece of Tagore's advice were dear and on occasions more than one he had to start almost alone for the cause dear to him. He ever felt the presence of God around him and, therefore, he never felt or feared that he was alone. H.D. Thoreau also said once that the man who goes alone can start today but he who travels with another must wait till that other is ready. Our young friends would bear with me that the schedules of combined study are seldom kept and adhered to. It has been rightly said that 'The strongest man in the world is he, who stands alone.'

Vacuum is against the Law of Nature . One receives only by giving. A controlled mind, born of meditation in aloofness, will tell us that by sending out good and helpful thoughts, we get the good and helping hands of others. In this way, the still mind keeps in constant company of good and thoughtful individuals. These words of Samuel Rogers are worth a heap of gold, "He only is alone, who lives not for others. Come what will, the generous man has his companion still." When alone, one can not sit idle, one must do one thing or the other and mostly constructive. The best things are produced under undisturbed conditions be they works of art, scientific invention, philosophies of life etc.

Napolean always went ahead, because he believed that those who proceed alone, proceed quickly.

Nature tells us the green grass is busy in searching its companions and keeps low, while the tree in isolation goes high to make researches in the sky above.

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THOUGHTS FOR THE MONTH

- He who does not want to win can not be defeated.
- One who praises you for qualities you lack, will next be found blaming you for faults not yours.
- There is but one way to worship God. It is to be devoid of evil.
- Work done to perfection is verily yoga.
- Few ever fail by trying, few ever win who quit.
- Our greatest glory is not in never falling but in rising every time we fall.
- Sooner or later the man who wins is the man who thinks he can.
- Genius, that power which dazzles mortal eyes, is oft but perseverance in disguise.
- Adversity is verily the prosperity of the great.
- It is often darkest before the day breaks.
- Kites rise against and not with the winds.
- Politics is a war without blood shed.
- Imitators do not make good, leave alone great leaders.
- Let justice remain blind and balanced.
- The world belongs to its people and not to its rulers.

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READERS' VIEWS

I am a regular reader of your highly informative magazine Competition Science Vision. I found CSV as a guardian for those students who are preparing for various Medical Entrance Examinations especially for CBSE, AIIMS and MGIMS. I think, the way Mother Teressa had served humanity, the Competition Science Vision has been serving the talented aspirants in building their career and achieving goal in life.

Its selected topics in Physics, Chemistry, Botany and Zoology are very informative for the students who are preparing for various Medical Entrance Examinations.

Bimlesh Kumar *Bokaro (Bihar)*

I have been a regular reader of your marvellous magazine CSV. It has inspired me to fulfil my dreams to become a doctor.

Competition Science Vision is an excellent career oriented magazine providing up-to-date information regarding Science.

I found General Mental Ability Test, Assertion and Reason Type Questions and Reasoning very useful for students preparing for Medical Entrance Exam.

Md. Mashooque Ali *Patna (Bihar)*

I have been a regular reader of your excellent and marvellous science magazine since August 1998. This Magazine really provides me with a lot of knowledge. Many topics like Science Tips, Memorable Points, Best Fifteen Questions and the other are very useful to us. It is really India's No. 1 Science Magazine.

Deepak Kumar *Allahabad (U.P.)*

I am a regular reader of your excellent magazine—Competition Science Vision. It is the best magazine of modern India. This magazine is read not only in India but also in Nepal.

Sanjay Singh *Katihar (Bihar)*

I have been a regular reader of your magazine since its inaugural issue. It has proved a boon for the medical aspirants. It touches each and every topic upto a very accurate depth.

Sumeet Mukherjee *Lucknow (U.P.)*

I have been a regular reader of CSV since its May issue. Really it is a unique magazine. In September, October, November and December issues, the interviews of topper have inspired me much. The notes on various topics in Physics, Chemistry and Biology are very helpful for us.

Anupriya Kumari *H.Bag (Bihar)*

I have been reading your magazine CSV since its inaugural issue.

I can say that it is the powerhouse of Knowledge on subjects like Science News, Memorable Points, True and False, Sports, Current G.K. and other topics on Biology, Chemistry & Physics as well as solved papers.

Md. Arif Azad *Gopalganj (Bihar)*

I am a regular reader of your unique magazine CSV. It is an excellent and marvellous science magazine. I specially like the topics Best Fifteen Questions, Typical Model Paper and Numerical Problems in Physics and Chemistry. I also like Editorial.

I would like to say that it is India's No. 1 Science magazine. It provides information and inspiration which are most important ingredients for success.

Arvind Bharti *Ranchi (Bihar)*

I am a regular reader of CSV since its first issue. According to me CSV is really a wonderful Science Magazine. This magazine has proved a boon for all medicos.

CSV is an elixir to quench the thirst of the science readers at the 10 + 2 level. It fully captures the reader's mind, packing his grey cells with all kinds of scientific knowledge.

Aradhana Tripathi *Kanpur (U.P.)*

I am a regular reader of CSV. It is a unique magazine for medical aspirants. Its Science News, Interviews of toppers, course materials, etc. are most beneficial for us.

Jitendra Kumar Singh *Ranchi*

I have been studying CSV since its October issue. I regard CSV as the best magazine for Medical Entrance Examinations.

I have not joined coaching for Medical Entrance Examination, but I can say that CSV is the best coach for me.

Nupur Vaijyanti *Lucknow (U.P.)*

I am highly impressed by all the topics of CSV as it includes lots of Model Papers, topics on different chapters of Biology, Physics & Chemistry and solved papers of Medical Entrance Examinations. CSV is a boon for all students who are preparing for Medical Exams. It helps digest difficult topics easily as the language is lucid. I personally feel that CSV is the best science magazine for Medical Entrance Exams.

Subhransu Roy *Muz. (Bihar)*

CSV is the best magazine for medical entrance exams. I am greatly impressed by the topics like "Our Young Talents, Science News, Latest General Knowledge and Typical Model Papers of Physics, Chemistry, Botany & Zoology."

Ashish Suman *Begusarai (Bihar)*

CSV is the best magazine for all medical aspirants and other science students. Model Test Paper, Science tips and all the subjectwise topics are very useful.

R.H. Khushtar *Patna (Bihar)*

I would like to say about the CSV that it is 'BRAHMASTRA' for medical aspirants. We can't win the war of Medical Entrance Exam. without it.

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I am a regular reader of your excellent, exhaustive and marvellous science magazine CSV. It is an echo of success. Everyone rejoices with its topics like Science News, Latest General Knowledge, Milestone of Science, Memorable Points, Science Tips, Topics on Physics, Chemistry, Biology, Model Test Paper, Solved Papers of different Medical Entrance Examinations, Reasoning in Physics, Chemistry, True or False, Fill in the Blanks and Assertion and Reason Questions.

Prabhat Ranjan Pintoo Nalanda (Bihar)

I am a regular reader of your unique magazine CSV right from its very beginning. I think it is the best magazine available in the market.

Md. Ibrar *Dhanbad (Bihar)*

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SCIENCE NEWS

Gene Causing Rheumatic Fever in Children Identified

The Indian Council of Medical Research (ICMR), in collaboration with different medical research institutions of the country, has succeeded in identifying the 'sick' gene which causes rheumatic fever in children, responsible for high mortality rate in India. ICMR Director N. K. Ganguly disclosed this while delivering a lecture on genetics at the fourth international symposium on Genetics, Health and Diseases at Guru Nanak Dev University, Amritsar. Dr. Ganguly said, he along with researchers at the Post Graduate Institute of Medical Education and Research (PGIMER), Chandigarh, had reported a genetic susceptibility marker of rheumatic fever which is present in 90 per cent of the patients suffering from this disease. Dr. Ganguli said there were at least 80 different types of streptococcal infections which cause sore throat in children but six has been identified as linked to defective genes.

Safe Diesel

Japanese scientists have developed a new fuel treatment that could reduce emissions from truck diesel engines. The technology could allow vehicle manufacturers to meet new emission standards. After 18 years of work the researchers perfected the liquid treatment, called **'Soltron'**. The US firm Solpower, based in Scottsdale, Arizona, has acquired North American manufacturing and marketing rights for the product. Soltron is a fuel enhancing fluid that works using enzymes. The makers claim the treatment affects molecules within liquid fuels—including diesel and gasolene—and increases the fuels' absorption of oxygen. The enzymes destroy the damaging contaminants that degrade normal fuels. Only three ounces of the treatment need to mixed with every 100 gallons of fuel for it to be effective. Emission tests conducted at the Environmental Testing Corp. in Orange, California showed that Soltron reduces hydrocarbon emissions by 55 percent, carbon monoxide by 37 percent, nitrous oxide by 44 percent and nitrogen chloride by 68 percent.

Pelletron

Pelletron, the 14 MV medium energy heavy ion accelerator (MEHIA) was set up under a collaborative project of the Bhabha Atomic Research Centre (BARC) and the Tata Institute of Fundamental Research (TIFR) at the campus of TIFR at Colaba, Mumbai, to pursue research in nuclear physics and allied disciplines.

Pelletron, the tandem electrostatic accelerator capable of providing beams of accelerated nuclear particles such as protons, alpha particles and different types of heavy ions at energies sufficiently high for conducting nuclear research, is a national facility open to all the users in the country.

Oceansat to be put in Orbit by March '99

In a giant leap forward in space technology, India will put into orbit in March 1999, an ambitious indigenously-developed satellite—Oceansat (P-4) to scan the ocean around the country. Dr. A. K. S. Gopalan, Director of the Space Application's Centre (SAC), said that work on the satellite was nearing completion at Ahmedabad and Bangalore. Launch from the Sriharikota range has been scheduled for March 1999. The launch of the Oceansat would put India in the company of the USA, Japan and the European union, which have already put satellites into orbit for study of oceans. Japan's satellite experiment, however, did not succeed.

The new satellite will help identify the species of fish available. Although similar experiments had been carried out earlier also, the Oceansat would improve data transfer in a better way so as to guide fishermen to the spot where they could find fish. Besides this, the Oceansat satellite will also study coastal dynamics.

Mars Express Mission

European space exploration is set to take a great leap forward in 2003 with a low-cost mission to the Red planet known as Mars Express, the European Space Agency (ESA) announced. The 60-Kilogram Mars Express is scheduled to land on the surface of Mars with a radar device which can analyse the planet's crust to a depth of 100 metre. Scientists believe there might be water on Mars and hope to find it in either liquid or frozen form. They are also searching for fossils which could indicate past life on the planet.

New Weapons

The US Army is developing two new weapon-systems—an electromagnetic rail gun and an electrothermal chemical gun and considering arming future vehicles with hypervelocity missiles. The electromagnetic rail gun, which could be fielded in 2015, would use an electronic power source similar to a car's alternator to generate tremendous amounts of energy in quick bursts to fire rounds. It could be machine-tested soon. The electrothermal chemical gun; which could be fielded in early 2005, will use an electronic power supply to generate an electrically neutral gas known as plasma, and would generate 30 times the energy of traditional tank guns to send around hurtling towards energy targets.

Copper-Wired Chips

The world's first commercial computer chips wired with copper instead of aluminium have begun shipping, according to International Business Machine Corp. which plans to market the faster chips for use in a wide range of computers and consumer electronics. Thus, IBM would incorporate copper chip technology into its flagship mainframe computer, minicomputer and workstation lines.

IBM has been engaged in a decade-long industry to create the first generation of copper-wired semiconductors, which can deliver improved performance and reduced power consumption compared to existing aluminium-wired chips. As engineers have packed more performance on to smaller devices, they have drawn closer to size and speed limits imposed by aluminium wires..

While designers consider aluminium easier to work with than copper, aluminium is a relatively poor conductor of electricity. As a result, in extremely small configurations, it cannot deliver sufficient power to the transistors.

Scientists looked to copper, a superior conductor, as a potential saviour but until recently it remained an elusive one because it was difficult to work with in small dimensions and could corrupt the silicon transistors in a chip.

Astronauts finish work on Space Station

Astronauts from the space shuttle Endeavour have ended their final day of work abroad the international space station, closing its hatches until another assembly crew arrives in about six months. The Endeavour's commander was Mr. Robert Cabana. The Crew moved quickly through their worklist and solved problems as they arose. The only mishap was an aluminium rack pin that floated away and was never found. All the planned objectives have been accomplished, during the crew's stay. They installed a communication system that provided two way video teleconferencing between the station and ground controllers.

Coffee aid

The next generation of anti-AIDS drugs could be based on a chemical extracted from green coffee beans, US researchers claim. Edward Robinson and his colleagues from the university of California made extracts from over 60 plants routinely used by medicine men of the Kallawaya tribes in Bolivia. They discovered that one of the extracts, chicoric acid, could prevent the Human Immunodeficiency Virus (HIV) from replicating within human cells. HIV infects the human cells by integrating its own DNA into that of the host cell, a process governed by the enzyme HIV intergrase. Chicoric acid interferes with this enzyme. The researchers hope to develop a drug based on a more powerful synthetic version of the chemical. The finding could be a major breakthrough in the treatment of AIDS, said Robinson. Current drug cocktails attack two other key enzymes responsible for promoting HIV replication, HIV protease and HIV reverse transcriptase. But severe side effects and viral resistance are limiting the effectiveness of these drugs. Chicoric acid could lead to the development of a new class of non-toxic AIDS drugs to which the virus has not developed resistance.

Phoney Conversation

Automated translation of phone calls has long been a dream of telephone companies. Now AT and T and Japan's Advanced Telecommunications Research Institute have joined forces to make it come true. By the end of 1999, they expect to have a prototype system that will automatically translate spoken Japanese into English, or vice-versa.

Fossilised reptile nests found

Researchers at the University of Colorado at Boulder and Emory University have discovered scores of ancient reptile nests, believed to be the oldest ever found, in Arizona's Petrified Forest National Park. The fossil nests dating to about 220 million years ago; are similar to modern day crocodile and turtle nests. Stephen Hasiotis and Anthony Martin discovered these nests. They believe the nests extend the fossil record of reptile nests by roughly 110 million years ago.

The 62 bowl-like depressions found by the researchers in sandstone deposits appear to be trace-fossils made by large, hole-nesting reptiles such as phytosaurs (primitive crocodile-like animals), aetosaurs (armored reptile from that period) or possibly ancient turtles. Located on the shoreline of an ancient river system, the nests which average about 12 inches wide and 18 inches deep are similar to modern day crocodile nests.

Breast Cancer Surgery using Ultrasonic Waves

Doctors at the All India Institute of Medical Sciences, have carried out for the first time in the world major breast cancer surgeries through a virtually bloodless procedure that uses ultrasonic waves. Doctors used ultrasonic or high-frequency sound waves to remove the entire breast with minimum loss of blood in 14 patients who were in advanced stage of breast cancer.

The ultrasonic waves delivered by an instrument called harmonic scalpal simultaneously dissects, cuts and coagulates tissues leading to minimum blood loss. Precise cutting and coagulation are achieved by adjusting the power level, blade edge and blade pressure.

A Pill for Shyness

British scientists have recently launched a pill for shyness : a remedy for social phobia. A team from Bristol and Southampton universities has successfully tested the pill, which could cure the estimated 3 million chronically shy people in Britain. At least 10 million others admit to social awkwardness.

The shyness pill works by increasing the level of serotonin in the brain, a chemical which induces a sense of euphorbia, boosts feelings of well-being and so improves people's self-confidence.

The drug, seroxal, was originally licensed to treat depression. However, David Wheatley, a consultant psychiatrist who carried out part of the chemical trial, said that improvements were noticed within a week. It seems that it is working on completely different chemical receptors in the brains of people suffering from social phobia.

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Latest General Knowledge

ABBREVIATIONS

SHCIL—Stock Holding Corporation of India Limited.

Andhra Bank has joined SHCIL's depository services by opening a beneficiary account for their own investments.

AKRPC—All Kerala River Protection Council.

Several river protection councils and AKRPC in Kerala have joined hands to fight the grave dangers threatening rivers in the state.

HAART—Highly Active Anti-Retroviral Treatment.

The drug regimen that has been found to work reasonably well and is followed all over the world, is the HAART.

AIDWA—All India Democratic Women's Association.

AIDWA gave a call to end caste system and untouchability and give equal rights to Dalits in the economic, social, political and legal spheres.

AWARDS

Honour for Professor—Lecturer of University Grants Commission, Professor Ram Murti Sharma, who is well known for his lectures on Vedanta, has been honoured this year with the prestigious 'Man of the Year' title. The award has been conferred to him by the American Biographical Institute of North Carolina. He has been awarded the title for his overall accomplishments and contributions to society.

Professor Sharma has delivered his lectures on Vedanta in Universities in Mexico, USA, UK, Australia, Thailand and Singapore. He has also been a fellow of Royal Asiatic Society, London. Prof. Sharma is a recipient of the President's certificate of Honour. He has also been honoured by the UP and Delhi Government.

National award for best book—'Nari Vigyan', authored by Dr. Yatish Agarwal and Ms. Rekha Agarwal, has been chosen by the Union Health Ministry for this year's national award for the best book in this category.

Awards presented to engineers—The Vice-President, Mr. Kishan Kant, presented the lifetime contribution awards for the year 1998 instituted by the Indian National Academy of Engineering (INAE).

The two lifetime contribution awards are given to eminent engineers who have made significant contributions to any branch of engineering and who have brought prestige to the nation. The awards in engineering were presented to Dr. Dara P. Antia for his contribution as metallurgist and management consultant and Prof. R. N. Dogra for its contributions as planner, achiever and educationist. The young engineer awards for the year 1998 were also given away on the occasion.

Agro-Forestry Award—Two Pune-based researchers, Dr. A. F. Mascarenhas and Dr. R. S. Nadgauda have been selected for prestigious 'Agro-Forestry Award', for 1998. The award instituted by cooperative Agro Forestry Federation, Nasik, and is given for outstanding dedication in the field of research related to agriculture.

Lata Mangeshkar Award—The prestigious Lata Mangeshkar award, instituted by the Madhya Pradesh Government, will be conferred on the noted music composer Mr. Ilayaraja for the year 1998.

Golden Pyramid Award—The Indian Film 'The Terrorist' has won all the top awards including the Golden Pyramid award for the best film at the 23rd Cairo International Film Festival. The director of the film in Tamil, Mr. Santosh Sivan, got the award for best direction while its heroine, Ms. Ayesha Dharker, bagged the actress award. The movie also won the international jury panel award for artistic creativity.

Vyas Samman Award—The K. K. Birla Foundation has selected Mr. Govind Mishra's novel titled "Paanch Anganon Wala Ghar' for its prestigious Vyas Samman award for the year 1998. The Vyas Samman is given to an outstanding Hindi literary work by an Indian citizen which has been published during the last ten years.

Maulana Jauhar awards for 1998—The Maulana Mohammad Ali Jauhar Academy announced the names of the awardees for the annual Maulana Mohammad Ali Jauhar Award '98.

Those to be honoured are Mr. N. D. Tiwari (former chief minister of UP), Mr. Bekal Utsahi (Urdu poet), Mr. Amod Kanth (IPS), Mrs. Shabana Azami (film star), Mohammad Khalil Ahmed (journalist) and Mr. A. M. Faheem (M/S Maktaba Al Hasanat).

Best Technological Invention Award—The eminent computer scientist Prof. J. R. Issac has been conferred the National Award for the Best Technological Invention. Prof. Issac was given this prestigious award for developing I-Learn, an educational system for the disabled, who cannot use the computer keyboard.

Bharat Ratna—Loknayak Jayaprakash Narayan has been posthumously awarded the Bharat Ratna, the country's highest honour. The award is being conferred for the 35th time.

EXHIBITIONS /SEMINARS/ CONFERENCES

'Innovative Australians' exhibition—'Innovative Australians', showcasing Australian science, technology and invention, with graphic panels, touch-screen consoles and other

innovations being used extensively to inform on a variety of science subjects, has been organised at the National Science Centre, New Delhi from 3rd December, 1998. 'Innovative Australians' is a joint initiative of Questacon—Australia's National Science and Technology Centre, IDP Education Australia, the Australia—India Council.

DAYS / WEEKS / YEAR

December 1—World AIDS Day

December 3—International Day of the Disabled Persons

December 4—National Navy Day

December 7—Armed Forces' Flag Day

December 16—Vijai Diwas

December 18—Minorities Rights Day

December 19—Goa Liberation Day

December 23—Kisan Diwas

BOOKS

The Global Business Game—Written by Mr. Trilok N. Sindhwani, discusses the basics of international business

Surviving Men—Written by Shobha De..It is the smart woman's guide and reflects the shifting gender relationship in India.

Brush With Life—The autobiography of Satish Gujral.

Across Borders—Former Foreign Secretary J. N. Dixit traces fifty years of India's Foreign Policy.

The World of Gender Justice—The first publication brought out by the Justice Sunanda Bhandare Foundation. It is a conglomeration of articles which throw light on the blatant and latent gender inequalities.

DEATH

K. Padmanabhan—Mr. K. Padmanabhan, former news editor of the Press Trust of India died at New Delhi on December 2, 1998, after a protracted illness. He was 85.

Kavi Pradeep—Renowned poet and Dada Saheb Phalke Award winner Ramchandra Narayanji Dwivedi popularly known as 'Kavi Pradeep', died at Mumbai. The ace poet, who won the country's top cinematic award for 1997-98, was 83.

Vinod Mishra—Mr. Vinod Mishra, one of the vanguards of the Naxalite movement, died at Lucknow on December 18, 1998, following a cardiac arrest. Mr. Mishra, general secretary of the CPI (ML) was 52.

PERSONS IN THE NEWS

Dominique Lapierre—After showcasing the poverty of Calcutta in his best-seller, 'City of Joy', writer Dominique Lapierre is busy doing welfare work in West Bengal. Now he and his wife sailed to some of the 57 scattered island-villages in the Sunderbans to dedicate the second boat dispensary to its four lakh inhabitants.

The first such dispensary, equipped with an operation theatre, X-ray machines, medicine storage facilities and manned by two doctors and two nurses, was commissioned around this time last year. He has, in the last 17 years, contributed over 6 million dollars for humanitarian work like creating medical and educational facilities for the poor, the physically handicapped, lepers and the mentally retarded in his 'City of Joy'. He once even sold his Paris apartment to raise money for social work when all other monetary sources were exhausted.

Mr. Lapierre said that the controversy over his film 'Mother Teresa—In the name of God's Poor', was created by some people around her and not the Mother herself.

Linor Abargil—Miss Israel Linor Abargil won the 1998 Miss World contest in Mahe Beach, Seychelles. Miss France placed second and Miss Malaysia third.

PLACES IN THE NEWS

Bangkok—Capital of Thailand was the venue of the 13th Asian Games from December 6 to 20, 1998.

Kuala Lumpur—Capital of Malaysia hosted the summit of the Asia-Pacific Economic Cooperation (APEC).

Jakarta—Capital of Indonesia, has seen some of its worst civil unrest and clashes with soldiers as people chant 'reformasi'.

APPOINTMENTS

Iraq names new envoy for India—Chief editor of Iraq's Al-Jumhuriya newspaper Salah Al-Mukhtar will be Baghdad's new Ambassador to New Delhi. Iraq also replaced its Ambassador to the United Nations, Nizar Hamdoon, as part of a sweeping diplomatic reshuffle. Hamdoon's job will go to said Al-Moussawi, a diplomat accredited to the UN.

Bhupendra Hazarika—Well-known Assamese singer and music composer and Dada Saheb Phalke award winner, Mr. Bhupendra Hazarika has been appointed the chairman of Sangeet Natak Academy. His appointment is for a period of five years.

UPSC Chairman–Lt. Gen. (Rtd.) Surinder Nath, Member of the Union Public Service Commission (UPSC), has been appointed its next chairman. Lt. Gen. Nath would replace Mr. J. M. Qureshi who will demit office on December 11, 1998. The tenure of Lt. Gen. Nath would commence from the date he assumes office and will have a term of three-and-a-half years.

Deputy Speaker—Mr. P. M. Sayeed of Congress (I) was unanimously elected Deputy Speaker of the Lok Sabha. The motion for Mr. Sayeed's election as 12th Deputy Speaker moved by the Prime Minister, Mr. Atal Behari Vajpayee and seconded by leader of the opposition Mr. Sharad Pawar. Leaders from all parties supported Mr. Sayeed's candidature.

Dilip Singh Bhuria—A tribal leader from Madhya Pradesh, Mr. Dilip Singh Bhuria has been appointed Chairman of the reconstituted National Commission for scheduled Castes and Scheduled Tribes by the Prime Minister, A. B. Vajpayee. Mr. Kameshwar Paswan, social activist from Bihar, will be Vice-Chairman. The commission will have a four-year term.

MISCELLANEOUS

India tops in milk production—India has emerged as the biggest milk producing country in the world now in its 50th year of Independence,

with annual milk production having increased from 20 million tonnes in 1970 to nearly 74 million tonnes this year. This was disclosed by the Union Minister of State for Agriculture, Mr. Som Pal.

Security advisory board constituted—Prime Minister Atal Behari Vajpayee constituted a 22-member security advisory board to assist the three-tier National Security Council headed by him to undertake a defence strategic review and decide on long-term policy options. The board consists of persons of eminence drawn from various specialised fields like foreign affairs and external security, defence, economics, science and technology, internal security and armed forces. Defence analyst K. Subrahmanyam, who is a part of the board, would be its convenor, some more names are under consideration and would be announced later. Former foreign secretaries Jagal Mehta, M. K. Rasgotra, Muchkund Dubey, J. N. Dixit and Lt. Gen. (Retd.) Afsir Karim have been appointed members from the category of foreign affairs and external security specialists.

Assembly elections—Assembly elections took place in the four states on November 25, 1998.

Assembly Election Results

Madhya Pradesh	
Total seats : 320	
Congress (I)	172
BJP	119
BSP	11
SP	4
IND/Others	14

Delhi	
Total seats : 69	
Congress (I)	51
BJP	15
JD	1
IND/Others	2

Rajasthan	
Total seats : 197	
Congress (I)	150
BJP	33
JD	3
BSP	2
CPI (M)	1
IND/Others	8

Mizoram	
Total seats : 40	
MNF	21
MPC	12
Congress (I)	6
BJP	...
IND/Others	1

Film Festival—The International Film Festival of India, to be held in Hyderabad from January 10, 1999. Among the retrospectives, 'Vision of India', there will be 20 pictures focussing on a variety of themes. Ten will be by foreign directors, such as Jean Renoir ('The River') and David Lean ('A Passage to India'). The section will also feature the German silent movie 'India Tomb'. Among the Indian entries will be 'Do Bigha Zameen', 'Bhumika' and 'Garam Hawa'.

Union Cabinet expanded—The Union Cabinet has been expanded on December 5. Mr. Jaswant Singh is the new Foreign Minister, while Mr. Pramod Mahajan will preside over the Ministry of information and Broadcasting and Mr. Jagmohan has been entrusted with the responsibility of the Ministry of Communications.

U.P. Minister sacked for 'Kalp Yojna'—The Uttar Pradesh Minister of State for Basic Education, Mr. Ravindra Shukla has been sacked for introducing 'Kalp Yojna' in the State's primary schools. Mr. Shukla's dismissal has brought to an anticlimatic end of the controversy over the introduction of compulsory singing of 'Saraswati Vandana' and 'Vande Mataram' in primary schools of Uttar Pradesh.

U. K. panel wants cloning of human embryos allowed—A high powered scientific committee has recommended that the cloning of early stage human embryos be allowed in Britain for research into new treatments for disease. A four-member committee of scientists that the Government had set up to look into the medical and ethical aspects of cloning, has suggested that the current rules restricting experiments with human embryos should be relaxed to allow research into the development of human tissues and organs that could be used for transplants as well as treatment of degenerative diseases. The committee has, however, opposed research into cloning for reproducting purposes. Critics argue that it will be difficult to separate the two.

The committee has argued that cloning of human embryos at a very early stage—around 8 to 10 days, will allow research into creating replacement tissues and organs that would avoid the normal problems of transplant rejection. It could also eventually lead to the creation of tissues that would help sufferers of degenerative diseases such as Alzheimers and Parkinsons.

Solzhenitsyn turns down Russian honour—Russia's Nobel prize winning author Alexander Solzhenitsyn has again snubbed the Kremlin, refusing to accept Russia's highest award conferred on him on his 80th birthday. The Russian President, Mr. Boris Yeltsin awarded Mr. Solzhenitsyn, who turned 80 with the order of St. Andrew instituted last year to honour eminent service to the nation. However, the renowned novelist said he could not accept the award from a regime which has brought Russia to ruin.

France launches education programme in India—The French Government has chosen India as the first country to launch the activities of its newly created agency, 'Edu-France', to promote higher education at an international level.

Integration of Europe had led to a joint declaration by Education Ministers of four countries—Britain, Italy, Germany and France—to recognise the diploma of the other countries. This declaration has now been signed by 12 European countries.

Private Internet Services in India—Satyam Online Ltd. of Hyderabad has become the first private Internet Service Provider (ISP) to start Internet services from the country. Satyam went on line at Andhra Pradesh's Hitech City that was inaugurated by Prime Minister Atal Behari Vajpayee. The company will be utilising VSNL gateways for international connectivity.

Exercise Shiv Shakti—India began its 10-day long 'Exercise Shiv Shakti' in the desert near the India-Pakistan border, the most sophisti-

cated of its kind in the country's military history. Jointly conducted by the Army and Air Force, it prepares the forces how to survive and win a nuclear and chemical war.

Russian Prime Minister Visits India—The Russian Prime Minister, Mr. Yevgeny Primakov arrived New Delhi on December 20 to give a long-term direction to political, military and economic ties against the backdrop of the U.S. bid to redraw the strategic map of the Persian Gulf. Highly placed sources point out that the U.S. attack on Iraq will influence the drift of political discussions during Mr. Primakov's two-day visit.

Maharastra tops in AIDS Cases—A total of 6690 Acquired Immuno Deficiency Syndrome (AIDS) cases were reported in the country this year, with Maharashtra notching the maximum of 3315, Minister of State for Health and Family Welfare, Dalit Ezhilm alai informed Rajya Sabha on December 18, 1998. Tamil Nadu follows, reporting 1624 cases and Manipur is next on the list with 301 cases.

SPORTS

Asian Games—The 13th Asian Games opened in Bangkok on December 6, 1998. Thailand's King Bhumipol Adulyadej used an ancient magnifying glass as a unique way of lighting the symbolic flame. The Asian Games attracted more than 6500 athletes from 41 nations. India's hockey Captain Dhanraj Pillay carried the Indian flag at the opening ceremony.

First Gold Medal–India's middle distance runner, Jyotirmoyee Sikdar, won the 1500 mts. race in four minutes, 12·82 seconds, to bag the first gold medal for the country in the Asian Games athletics event in Bangkok on December 14. Sunita Rani, also from India bagged the bronze medal, while Wang Qingfen of China won the silver.

Third straight Kabaddi gold for India–Defending well, reigning champions India outclassed Japan 59-25 to retain the Asian Games Kabaddi gold for the third successive time. This was Indias second gold at the 13th Asian Games, after Jyotirmoyee Sikdar won 1500 metre race.

India won the inaugural Kabaddi gold in 1990 at Beijing and then in 1994 at Hiroshima and repeated the performance for the third time.

Sachin among 10 all-time great batsman—India's Cricketer Sachin Tendulkar has been nominated as one of the top ten batsman by an Australian newspaper. Tendulkar figures a spot below former opener Sunil Gavaskar, in a list of the ten greatest batsman compiled by the Sun Herald.

The list is headed by Sir Don Bradman (Australia) followed by Sir Garfield Sobers (West Indies), Victor Trumper (Australia), Len Hutton (England), Vivian Richards (West Indies), Greg Chappell (Australia), Neil Harvey (Australia), Everton Weekes (West Indies) and the Indian duo.

India regains hockey gold—India regained the Asian Games men's hockey gold after 32 years when it edged out the holder, South Korea, 4–2 in the penalty stroke shoot-out after the two teams were deadlocked 1-1 at the end of regulation time and 15 minutes extra time in the final at Bangkok on December 19. Indian goalkeeper Ashish Ballal was the hero of the match, saving two strokes.

In 1966, India beat its arch-rival, Pakistan 1-0 in the final and since then it had settled for the runner-up position to the Pakistan. India had won the bronze in 1986 at Seoul and then was confined to the silver standard in 1990 at Beijing and in 1994 at Hiroshima before regaining the title now to round off an outstanding tournament where it emerged victorious in all the matches in the league and knock-out stages. The Indians had beaten the Koreans in the league stage before providing an encore in the all important final.

Indian athletes won 35 medals in Asian Games—Thai Crown prince Maha Vajiralongkorn formally closed the 13th Asian Games at Bangkok on December 20. South Korean coastal city Pusan will host the 14th Asian Games in 2002.

Athletes from India brought home 7 gold, 11 silver and 17 bronze medals and perhaps most important India's first gold in men's field hockey in 32 years.

Star of the Asian Games—Japanese sprinter Koji Ito was voted the star of the Asian Games, adding a 100000 dollar cheque to his three gold medal. He won the 100 m in an Asian record time of 10·00 sec. as well as the 200 m in a Games record 20·25 sec. and played a key role in Japan's winning 4 × 100 m relay team.

Athletes of the Year—World sprint champion Marion Jones of the U.S. and 5000 m world record holder Haile Gebreselassie of Ethiopia were named Athletes of the year 1998.

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'Wings of Fire' : An Autobiography of APJ Abdul Kalam

AVUL PAKIR JAINULABDEEN ABDUL KALAM has come to personally represent to many of his countrymen the best aspects of Indian life. Born in 1931, the son of a little educated boatowner in Rameswaram, Tamil Nadu, he had an unparalleled career as a defence scientist, culminating in the highest civilian award of India, the Bharat Ratna. As chief of the country's defence research and development programme, Kalam demonstrated the great potential for dynamism and innovation that existed in seemingly moribund research establishments. This is the story of Kalam's own rise from obscurity and his personal and professional struggles, as well as the story of *Agni*, *Prithvi*, *Akash*, *Trishul* and *Nag*—missiles that have become household names in India and that have raised the nation to the level of a missile power of international reckoning.

At the same time as he has helped create India's awesome weaponry, Kalam has maintained the ascetic rigour of his personal life, working 18 hours a day and practising the veena. With characteristic modesty, Kalam ascribes the greatness of his achievements to the influence of his teachers and mentors. He describes the struggles of his boyhood and youth, bringing alive everyday life in a small town in South India and the inspirational role of educators. He describes the role of visionary Indian scientists, such as Dr. Vikram Sarabhai and of the creation of a coordinated network of research institutions. This is also the saga of independent India's struggle for technological self-sufficiency and defensive autonomy—a story as much about politics, domestic and international, as it is about science.

MILESTONES OF SCIENCE

3D Radar

A pioneering radar system from the Daimler-Benz Research Centre can see the world in 3D and thereby alert motorists to hazards and obstacles in the road before it is too late. Connecting up an array of radar sensors enabled scientists to obtain information about not only the relative distance and speed of various objects on the roads but also their size and extension. Once, the 3D radar image has been processed and evaluated by the computer, the picture obtained is so precise that the driver can even recognise details such as where the road surface ends and gravel or grass begins. Since, the underside of an automobile and the surface of the road are able to reflect radar waves, the latter can pass beneath vehicles up ahead much in the same manner as light in a fibre optic cable. It is a useful trick that allows the radar to detect objects located far beyond the driver's normal range of vision. By the new system, the vehicle directly infront of the driver is thus rendered 'transparent'.

Green Guards

Hal Philipp, a IBM researcher based in Southampton has produced a unique burglar alarm using house plants. He has converted these plants into sensors simply by connecting them to an electrical circuit. Philipp has invented a particular type of electronic capacitance sensor which when used in house plants could act as a capacitor—accumulating an electrical charge and discharging it. The capacitance sensor is normally charged and discharged many times to establish an average reference level. This allows engineers to tune the alarm to ignore harmless changes in capacitance—such as those caused by changes in humidity and react only to the distinctive changes in capacitance that are caused by intruders creeping past the plant.

The alarm is so designed that it ignores the background noise but still responds to small changes in capacitance. A company called Quantum Research has been formed for producing a commercial version of the alarm. As most objects can hold a charge, almost anything can be a sensor. This technique may turn out to be particularly useful for protecting works of arts in museums. Any one touching a valuable article would immediately trigger an alarm.

Electronic Nose

It is necessary that treatment commence only after the correct diagnosis has been made, it is equally significant that the time taken for diagnosis be kept minimum. In light of this, scientists have been striving hard to develop an electronic nose having the ability to sniff out some common disease causing bacteria. This nose is so very perfect that it can easily identify the bacteria responsible for ear, nose and throat infections.

The electronic nose, developed at Warwick University, has an array of sensors to pick up the odour from growing bacteria. The pattern of response is compared with patterns from known smells through a neural network programme. This fast and accurate system can also be used to detect infections in different parts of the body.

Glove for Cleaning and Disinfecting

Russian researchers, have come up with a multi-purpose handglove for cleaning and disinfecting smooth surfaces like furniture, windows, mirrors, faucets and files. The glove polishes smooth surfaces, removes dirt, superficial rust and static electricity from them, and covers them with a protective film that stays on for a long time. It takes 15 minutes for it to wash a car. One glove can wash about 50 cars and polish 600 cars. It can make the use of antistatics obsolete. The glove need not be washed with water as it would disrupt the composition of the chemical impregnator. It only requires beating to remove dust and dirt out of it. One side of the glove is covered with dark soft hairs or naps, which are located at a certain angle, to accumulate dust. The other side consists of a specially designed corrugated cotton fabric. It would be useful for museums and art galleries as it offers protection to showcases, exhibits, marble and floors against damage and it could be useful in libraries, hospitals and schools.

Ring-pull Powered Telecoms

German designer has developed wind-up mobile phones that never need recharging could soon be on the market. The new phone gets power from a generator that is driven by a ring-pull, similar to those used on children's toys to power voice recordings. Before making a call, the user pulls a cord attached to the generator about 15 times. This stores enough energy in the phone for a five-minute conversation. It needs far less electric power than a normal phone. The disc-shaped phone has a pull-down microphone and a keypad arranged around the side. The talker recognises speech and users can call, anyone in its address book by simply saying a name into the phone's flip-out microphone. The system is also able to read out any text or e-mail messages sent to the phone.

Soya Oil Composite

Scientists have developed a technique for using soyabean oil to produce inexpensive lightweight and potentially biodegradable composites for manufacturing tractors, supercars, bridges and military vehicles. Their technique involves chemically modifying soya oil. The soya-based resin and reinforcing fibres such as glass may then be injected into a mould, where the liquid solidifies to form composite. The composit would not corrode or rust and it was made using low-energy procedure that is far more benign than metal casting systems. It is structurally comparable to metal, but at lower cost, while its lower weight provides better fuel efficiency. ●●●

MEMORABLE POINTS

- A perceived regularity in the results of experiments that can be represented by an equation or formula is known as **—Experimental law**
- A suggested explanation that has not been subjected to extensive testing is known as **—Hypothesis**
- A systematic statement of a principle that has been verified by repeated experiments is known as **—Theory**
- A statement to which there are no known exceptions is known as **—Scientific law**
- The first breakthrough in the study of chemical reactions came into being with the statement that the mass is conserved in a chemical reaction. This statement is due to **—French chemist Antoine Lavoisier (1794)**
- Development of abnormal structures in an embryo is known as **—Teratogen**
- Cholecalciferol is commonly synthesized from 7-dehydrocholesterol; that is why, 'D' vitamins are called **—Sunshine vitamins**
- Vasopressin (antidiuretic hormone) is a peptide hormone produced by the **—Hypothalamus and the posterior pituitary gland**
- Somatomedin is a polypeptide hormone produced by the action of growth hormone on the liver and kidneys. It mediates the action of growth hormone on **—Cartilage**
- Pseudoallele is a mutation in a gene that produces an effect identical to another mutation in the same gene locus. The two pseudoalleles thus act as a single gene but do not occupy the same **—Position**
- Diverse, complex organisms appear in the fossil record about 600 million years ago perhaps as a result of the evolution of multicellularity in association with **—Sexual reproduction**
- The cells of endodermis are living and are characterised by the presence of **—Casparian strips or bands**
- When the substrate is fat, the respiratory quotient becomes **—Less than one**
- Duplication of centromere and appearance of fibrils between the daughter centromere is the feature of beginning of **—Anaphase**
- Lysosomes are bounded by a single limiting membrane of **—Lipoprotein**
- Each contributing allele, in polygenic inheritance, has a quantitative effect on the phenotype, therefore, the allelic effects are **—Additive**
- To describe a gene that affects more than one characteristic of the individual is termed as **—Pleiotropy**
- In cauliflower, the Brown Heart disease is caused due to deficiency of **—Boron**
- Near absolute zero, liquid helium loses all viscosity. This effect is called **—Superfluidity**
- The temperature below which the superfluidity occurs is called the **—Lambda point**
- Lambda point for $_2He^4$ is **—2.172 K**
- The Joule-Kelvin effect produces cooling below a certain temperature of a gas called **—Inversion temperature**
- A real gas can be liquefied by compressing it; provided it is below its critical temperature, the pressure to liquefy it at this temperature is called **—Critical pressure**
- A gas below its critical temperature is called a **—Vapour**
- Critical temperatures of helium, hydrogen (H_2) and oxygen are respectively **—5K, 33K, 155 K**
- The expansion of gases was investigated by Charles and Gay-Lussac. Their results suggested that all gases should have zero volume at **—273·15°C**
- The high frequency waves that are reflected by the ionosphere and the earth are called **—Sky waves**
- The electromagnetic waves used to carry sound and picture signals over long distances are the **—Radio waves**
- In an electronic circuit the signals that produce a voltage which varies continuously over a range of values are called the **—Analogue signals**
- The pulses that are produced because a circuit's output voltage is either High or Low and that can be represented by the logic numbers 1 and 0 are called **—Digital signals**
- The device that removes the radio-frequency part of a signal and passes only the audio frequency part is known as the **—Demodulator**

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SCIENCE TIPS

Physics

1. In projectile motion, the horizontal motion is a uniform motion, what about the nature of vertical motion ?

—Vertical motion is uniformly accelerated motion

2. What is the nature of trajectory of a body thrown horizontally from a certain height above the ground till it hits the ground.

—Trajectory is parabolic

3. Range of a projectile for two angles α and β of projection is the same. What is the relation between α and β ?

—$\alpha + \beta = 90°$

4. What is the unit and the dimensional formula of angular velocity ?

—radian/second $[T^{-1}]$

5. What is the relation between linear velocity and angular velocity ?

—$v = r\omega$

6. When is the tension maximum in the thread of a simple pendulum performing S.H.M. ?

—Tension is maximum when the thread is vertical

7. The angular momentum of a body about the axis of rotation is given by $J = I\omega$. What is its rate of change with time equal to ?

—Torque C

8. A body falls on earth from infinity, what will be its velocity on reaching the earth ?

—11·2 km/sec

9. What is impulse-momentum theorem ?

$$-\int_0^t \vec{F}\,dt = \vec{p}_2 - \vec{p}_1$$

10. A rocket burns 50 gm of fuel per second ejecting it as a gas with a velocity of 5×10^5 cm s^{-1}. What force is exerted by the gas on the rocket ?

—250 N

11. On a convex bridge when is a car lighter, while moving or while standing on it ?

—On a convex bridge car is lighter when it is moving

12. The moment of inertia of a disc about a diameter is $\frac{1}{4}MR^2$. What will be its moment of inertia about an axis parallel to the diameter and touching the edge of the disc ?

—$\frac{5}{4}MR^2$

13. You have two condensers of capacity 1 μF each. You need a capacity of $\frac{1}{2}\mu$F. What shall you do ?

—Connect the condensers in series

14. What is defined as the 'relative number of atoms decaying per second'.

—Decay constant λ

15. What is the reciprocal of the time, when N/N_0 falls to $\frac{1}{e}$, called ?

—Decay constant λ

16. If t is the time of n half lives of a radioactive substance whose half-life is T, starting from N_0 atoms in the beginning what will be the number of atoms N left after n half-lives ?

—$N = N_0 \left(\frac{1}{2}\right)^{t/T}$

17. A certain element has a half life of 30 days. What is its average life ?

—43·28 day

18. Name five elements which lie on peaks in binding energy curve.

—$_2He^4$, $_4Be^8$, $_6C^{12}$, $_8O^{16}$ and $_{10}Ne^{20}$

19. Momentum p can be associated with a particle and λ is associated only with a wave. Who established a relation between the two ?

—de Broglie

20. What is the frequency of a photon of energy $3·3 \times 10^{-20}$ J ?

—$0·5 \times 10^{14}$ Hz

Chemistry

21. The weight of the substance deposited by the passage of 1 coulomb of electricity is known as

—Electrochemical equivalent

22. What is meant by 1 mole of electrons ?

—$6·023 \times 10^{23}$ electrons

23. The ratio of the masses of reactants which react according to known chemical equation is termed as

—Stoichiometry

24. For a reaction at equilibrium, the net reaction rate will be

—Zero

25. The physical properties of a crystal change with change of direction of measurement. This phenomenon is known as

—Anisotropy

26. A pleasantly smelling liquid obtained by mixing ethanal and ethanol in presence of acid catalyst is known as

—Acetal

27. A seaweed colloid, a mixture of two polysaccharides, agarose and agaropectin, is known as

—Agar-agar

28. What is quark ?

—Fundamental subatomic particle

29. What is **rinmann's green ?**

—$ZnCo_2O_4$

30. A titanium mineral (TiO_2) used in ceramics, is known as.

—Rutile

31. The post-actinium element with atomic number 104 is also known as

—Rutherfordium

32. The isomers formed by restricted rotation are known as

—Rotamers

33. A major photosensitive pigment of eyes is

—Rhodopsin

34. What is a **solid solution** ?

—When two or more elements share a common lattice

35. Sodium ammonium hydrogen phosphate is known as

—Microcosmic salt

36. An oxide which contains O_2^- ion is termed as

—Superoxide

37. The polymers in which the substituents alternate regularly between the two sides of the polymer backbone, are known as

—Sydiotactic

38. What is **thermal neutron** ?

—Slow neutron

39. A process in which finely divided ore is heated until it collects in form of larger particles is known as

—Sintering

40. A reaction between fat and caustic soda is known as

—Saponification

Zoology

41. Coiled portion of internal ear containing organ of hearing.

—Cochlea

42. Mesentery that supports testes.

—Mesorchium

43. Connective tissue cord containing blood vessels that unites mammalian embryo or foetus with placenta.

—Umbilical cord

44. An enzyme involved in light production in organisms.

—Luciferase

45. Voice box of a bird

—Syrinx

46. A cancer-causing gene, that cause cells to exhibit rapid, uncontrolled proliferation.

—Oncogene

47. The biosynthesis of a carbohydrate from simpler, non carbohydrate precursors such as oxaloacetate or pyruvate.

—Gluconeogenesis

48. A DNA sequence at which RNA polymerase may bind, leading to initiation of transcription.

—Promoter

49. A class of glycoproteins with antiviral activities.

—Interferons

50. Alternation of sexual and asexual reproduction in the life cycle of certain animals;

—Alternation of generation

51. The gelatinous filling between the outer and inner cell layer of a two layered animal such as a jellyfish.

—Mesoglea

52. An enzymatic cofactor derived from pterin and involved in certain oxidation reduction reactions.

—Biotin

53. An aggregate of amphipathic molecules in water with the non-polar portions in the interior and the polar portions at the exterior surface, exposed to water.

—Micelle

54. A coelenterate polyp with mouth and tentacles.

—Hydranth

55. The coelom formed by the splitting of embryonic mesoderm

—Schizocoel

56. A method of gastrulation by which the smaller blastomeres at the animal pole of the embryo over and enclose the cells of the vegetal hemisphere.

—Epiboly

57. An individual chromatid in a chromosome.

—Chromomere

58. A movement response to air or water current

—Rheotaxis

59. The coelom filled with haemolymph

—Haemocoel

60. An extension from the subumbrellar surface of jelly fish

—Manubrium

Botany

61. Who placed gymnosperms between dicots and monocots as third taxon ?

—Bentham and Hooker

62. What are the two major groups of plant kingdom of Bentham and Hooker's classification ?

—Cryptogams and Phanerogams

63. Who was the first person to study mitosis cell division ?

—Walter Fleming

64. Who reported dihybrid experiment in sweet pea (*Lathyrus odoratus*) ?

—Bateson and Punnett

65. What is hypertrophy ?

—Enlargement of a tissue or organ due to an increase in the size of its cells or fibres.

66. In which form plants absorb minerals ?

—In the form of ions

67. What does ICBN stand for ?

—International Code of Botanical Nomenclature

68. What are capsomeres ?

—Viral coat (capsid) surrounding the nucleic acid built up of identical repeating subunits called capsomeres

69. What are the main components of nucleotides ?

—Nitrogenous base (purine or pyrimidine), a phosphate and a pentose sugar

70. What is a gene ?

—A series of nucleotides of DNA that code for a single molecule.

71. Where does energy capturing reaction occur ?

—In the thylakoid

72. Who found that an increase in the dry weight of a plant was dependent upon the presence of carbon-dioxide ?

—Nicholas de Saussure

73. Where does substrate-level phosphorylation occur ?

—In glycolysis and Kreb's cycle

74. What is acetyl-Co A ?

—A molecule made up of a two carbon acetyl group attached to coenzyme A.

75. What is the chief function of FAD ?

—It functions as an electron acceptor in cellular oxidation reduction reactions.

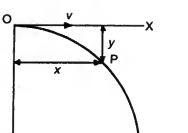
HINTS

1. The motion of a projectile is two dimensional motion consisting of (i) horizontal motion and (ii) vertical motion. Hence, at any instant, the velocity of a projectile has two components (i) horizontal component and (ii) vertical component.

   The horizontal component remains unchanged throughout the flight as there is no acceleration in horizontal direction. The vertical component is continuously affected by the force of gravity. Thus, the horizontal motion is uniform motion but the vertical motion is uniformly accelerated motion.

2. Let the body be thrown horizontally from point O with a velocity v. Let the body be at point P at some instant t. Then

$$x = vt$$



and $$y = 0 + \frac{1}{2} g t^2$$

$$\therefore \quad y = \frac{1}{2} g \frac{x^2}{v^2}$$

$$= kx^2 \text{ where } k = \frac{1}{2}\frac{g}{v^2} \text{ is a constant}$$

This equation represents a parabola.

3. Range of a projectile is given by

$$R = \frac{u^2 \sin 2\theta}{g}$$

Substituting $(90° - \theta)$ in place of θ

$$R = \frac{u^2 \sin 2(90 - \theta)}{g}$$

$$= \frac{u^2 \sin (180 - 2\theta)}{g}$$

$$= \frac{u^2 \sin 2\theta}{g}$$

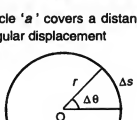
Thus, there are two angles of projection $\alpha = \theta$ and $\beta = (90° - \theta)$ for which the projectile has same range; clearly $\alpha + \beta = 90°$

4. ω = rate of change of angular displacement

$$= \frac{d\theta}{dt}$$

Clearly unit of ω is rad/sec and its dimensional formula is $[T^{-1}]$ since angle is a dimensionless quantity.

5. Let the particle 'a' covers a distance Δs in time Δt. Then the angular displacement



$$\Delta\theta = \frac{\Delta s}{r}$$

or, $$\frac{\Delta\theta}{\Delta t} = \frac{1}{r}\left(\frac{\Delta s}{\Delta t}\right)$$

In the limit when $\Delta t \to 0$

$$\frac{\Delta\theta}{\Delta t} = \omega$$

and $$\frac{\Delta s}{\Delta t} = v$$

$$\omega = \frac{1}{r} \times v$$

or, $$v = r\omega$$

6. Tension, when it has displacement θ, is given by

$$T = mg\cos\theta + \frac{mv^2}{l}$$

In vertical position of the thread $\theta = 0$.

Hence, the tension becomes

$$T' = mg + \frac{mv^2}{L}$$

Clearly T' is maximum as cos θ decreases when θ increases.

7. Torque $C = I\alpha$

where α is angular acceleration.

$$\therefore \quad C = I\frac{\Delta\omega}{\Delta t}$$

Also $J = I\omega$

$$\therefore \quad \frac{\Delta J}{\Delta t} = I\frac{\Delta\omega}{\Delta t} = C$$

8. A body projected up with the escape velocity v_e will go to infinity, therefore, the velocity of the body falling on earth from infinity will be v_e. Now escape velocity on the earth is

$$v_e = \sqrt{2gR_e}$$
$$= \sqrt{2 \times 9{\cdot}8 \times 6{\cdot}4 \times 10^6}$$
$$= 11{\cdot}2 \times 10^3 \text{ m/s}$$
$$= 11{\cdot}2 \text{ km/s}$$

9. From Newton's second law of motion

$$\vec{F} = \frac{d\vec{p}}{dt}$$

$$\vec{dp} = \vec{F}dt$$

Integrating $$\int_{p_1}^{p_2} \vec{dp} = \int_0^t \vec{F}dt$$

where $\vec{p_1}$ is the momentum at $t = 0$ and $\vec{p_2}$ is the momentum at time t.

$$\left[\vec{p}\right]_{p_1}^{p_2} = \int_0^t \vec{F}dt$$

or, $$\vec{p_2} - \vec{p_1} = \int_0^t \vec{F}dt$$

Thus, $$\int_0^t \vec{F}dt = \vec{p_2} - \vec{p_1}$$

Hence, the impulse of a varying force is equal to change in momentum produced by the force.

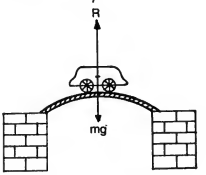
10. $$v_r = 5 \times 10^5 \text{ cm/s}$$
$$= 5 \times 10^3 \text{ m/s},$$
$$\frac{\Delta m}{\Delta t} = \frac{50}{1000} \text{ kg/sec}$$

Upward thrust on the rocket

$$= v_r\frac{\Delta m}{dt} = 5 \times 10^3 \times \frac{50}{1000}$$
$$= 250 \text{ N}$$

11. On a convex bridge car moves on a segment of a circle. The centripetal force is provided by the difference of weight mg of the car and the normal reaction of the bridge.

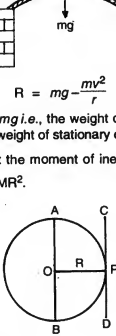
$$\therefore \quad mg - R = \frac{mv^2}{r}$$



$$R = mg - \frac{mv^2}{r}$$

Clearly R << mg *i.e.*, the weight of the moving car is less than the weight of stationary car.

12. We know that the moment of inertia of disc about a diameter is $\frac{1}{4}MR^2$.



Applying theorem of parallel axes, the moment of inertia of the disc about an axis parallell to diameter AB and touching the edge of the disc

$$= \frac{1}{4}MR^2 + MR^2 = \frac{5}{4}MR^2$$

13. When condensers are connected in series, the equivalent capacity is given by

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2}$$
$$= \frac{1}{1} + \frac{1}{1} = \frac{2}{1}$$

$$\therefore \quad C = \frac{1}{2}\mu F.$$

14. According to the laws of radioactive decay

$$\frac{dN}{N} = -\lambda\, dt$$

If $$dt = 1 \text{ sec},$$

$$\frac{dN}{N} = -\lambda$$

Thus, λ may be defined as the relative number of atoms decaying per second.

15. $N = N_0 e^{-\lambda t}$

If $t = \frac{1}{\lambda}$,

$N = N_0 e^{-1}$

or, $\frac{N}{N_0} = \frac{1}{e}$

Thus, λ can also be defined as the reciprocal of the time when N/N_0 falls to $1/e$.

16. We know that $N = N_0 \left(\frac{1}{2}\right)^n$

If t is the time corresponding to n half lives, then

$t = nT$

or, $n = \frac{t}{T}$

$\therefore \quad N = N_0 \left(\frac{1}{2}\right)^{t/T}$

17. Average life τ is given by

$\tau = \frac{1}{\lambda}$ where λ is decay constant

Also half-life

$T = \frac{0{\cdot}6931}{\lambda} = 0{\cdot}6931\ \tau$

$\tau = \frac{T}{0{\cdot}6931} = \frac{30}{0{\cdot}6931}$

$= 43{\cdot}28$ day

18. Between mass number 4 and 20, the binding energy curve shows cyclic recurrence of peaks at ${}_2He^4$, ${}_4Be^8$, ${}_6C^{12}$, ${}_8O^{16}$ and ${}_{10}Ne^{20}$. This shows that the binding energy per nucleon of these nuclides is greater than those of their immediate neighbours. So, these are more stable as compared to their neighbours. Note that mass number of these nuclides are multiples of 4 and they contain equal number of protons and neutrons. Each of these nuclei can be formed by adding an α-particle to the preceding nucleus.

19. Combining Einstein's mass-energy equivalence ($E = mc^2$) and Planck's quantum theory ($E = h\upsilon$) we get

$E = h\upsilon = mc^2$

But $c = \upsilon\lambda$ for waves, thus for a quantum of light (photon)

$E = h\frac{c}{\lambda} = mc^2$

$\lambda = \frac{h}{mc} = \frac{h}{p}$

This relation is for a photon, it occurred to de Broglie that what is true for a photon, may also be true for a material particle of mass m with velocity v (not c).

$\therefore \quad \lambda = \frac{h}{mv}$

20. $\upsilon = \frac{E}{h} = \frac{3{\cdot}3 \times 10^{-20}}{6{\cdot}6 \times 10^{-34}}$

$= 0{\cdot}5 \times 10^{14}$ Hz

●●●

Third Topper and First position holder in Girls in B.C.E.C.E. (Bihar)-98

Miss Kusum Kumari

Competition Science Vision arranged an extensive and broad based interview with Miss Kusum Kumari who has the credit of securing third position in B.C.E.C.E., 1998 bagging the first position among girl candidates. Below we give in her own words her planning for such a brilliant success in the examination.

CSV—Congratulations on your brilliant success.

Kusum—Thank you very much, Sir.

CSV—Before knowing your result what did you think about those who achieve top positions ?

Kusum—For me, they seem to be very brilliant students. They always used to inspire me to do something great.

CSV—Achieving top position has come as a surprise to you or you were confident of achieving it ?

Kusum—Not at all. I always took myself as a moderate student, but yes something inside me assured me of coming out with flying colours.

CSV—What do you think is the secret of your success ?

Kusum—My hard labour, blessing of my parents, good wishes and, of course, blessings of the Almighty.

CSV—In how many attempts did you get this success ?

Kusum—In three attempts.

CSV—What were the shortcomings in your preparation for earlier attempts ? How did you make up for them this time ?

Kusum—I was not getting the right directions. I made up this time by being very intensive in study.

CSV—From where did you get the inspiration of choosing a medical career ?

Kusum—Seeing the pathetic conditions of poor and ill people, I always wanted to do something for them, which can be done very nicely as a doctor only.

Kusum—I just studied the selective topics as per the syllabus of the B.C.E.C.E.

Bio-Data

Name—*Kusum Kumari*

Father's Name—*Sri. Kuldip Prasad*

Mother's Name—*Smt. Saroj Devi*

Educational Qualifications—

H.S./Std.X—74% (Govt. Girls High School Itki (Ranchi), 1993.

Inter/Std. XII—60% (Ranchi Women's College, Ranchi 1995.)

—Competition Science Vision is a very good magazine. It is very useful for those preparing for medical competition examinations.
—Kusum

CSV—Since when did you start the preparation for it ?

Kusum—Since beginning of XI class.

CSV—What planning did you make for preparation ? Please tell something in detail.

Kusum—I had just planned a regular routine of study and also to devote equal time for all the subjects. I had planned not to take interest in any one subject only but to pay attention to all the subjects in a very balanced manner.

CSV—How much time did you devote daily and regularly for Physics, Chemistry, Botany and Zoology ?

Kusum—At least 8 hours a day, but with intervals.

CSV—Out of the above four subjects, to which subject did you give more weightage and why ?

Kusum—Physics, because I think this is generally the determining subject in all the competitions. Other subjects are comparatively easier and in general one can easily attempt questions from them.

CSV—Did you make complete study of all topics or of some selective topics ?

CSV—How did you give final touches to your preparation ?

Kusum—I studied from my personal notes and the highlighted parts from the books.

CSV—Did you prepare notes ?

Kusum—Yes, but not much. I prepared reading books again and again.

CSV—What was your attitude for solving numerical questions ? What weightage did you give them ?

Kusum—I enjoyed solving numerical questions. I take them as a determining factor because they are a bit different from other questions.

CSV—How much time is sufficient for preparing for this examination ?

Kusum—One can do it while studying in XI or XII class itself and giving just a few hours extra for solving objective questions.

CSV—From what level of education should an aspirant begin preparing for it ?

Kusum—After X board examination itself.

CSV—Please mention various books in each subject and magazines on which you based your preparation.

Kusum—Physics—Sanjeev Gupta.
Chemistry—O. P. Agarwal
Zoology—S. P. Kurl
Botany—A. K. Sharma

CSV—Did you take coaching in your preparation ?

Kusum—Yes, from 'CITY WIDE STUDY CIRCLE', in Ranchi.

CSV—What help do the science magazines render in the preparations for this examination ?

Kusum—They do render a great help in preparation especially the topper's interview and question bank help a lot.

Personal Qualities

Hobby/Hobbies—*Reading magazines, playing chess.*
Ideal Person—*My father and Mahatma Gandhi.*
Strong Point—*Hard labour.*
Weak Point—*I am an introvert.*

CSV—What is your opinion about our Competition Science Vision ? How much helpful and useful do you find it ?

Kusum—It is a very good magazine. It is very useful for those students who are preparing for medical competitive examinations.

CSV—Please suggest in what way CSV can be made more useful for medical aspirants ?

Kusum—It should be based on medical competitive examinations.

CSV—Please mention your position in the merit list.

Kusum—I was the third topper.

CSV—Whom would you like to give credit for your success ?

Kusum—My hard labour, self confidence, my parents and my elder brother.

CSV—Please tell us something about your family.

Kusum—Father is Science teacher in Chatti High School, Lohardagga.

Mother is an A.N.M. nurse in Ranikhatanga of Bero Block.

Elder Sister—A pharmacist.

CSV—What message would you like to give to our readers of CSV ?

Kusum—Please, study very hard at the time of preparations, you should be very sincere and honest to yourself and to your hard work. ● ● ●

At a Glance

Bacterial Diseases

Cholera

- *Causes of Emergence* : Recent epidemic in South America introduced from Asia by ship; spread by travel and inadequate water chlorination; poor sanitation.
- *Mode of Transmission* : Ingestion of water contaminated with feces of infected persons; ingestion of food exposed to contaminated water.
- *Symptoms* : Severe diarrhea, rapid dehydration.
- *Treatment/Prevention* : Recent strains resistant to several antibiotics.

Escherichia Coli 0157:H7 (E. coli)

- *Causes of Emergence* : Contamination of meat during butchering process; spread by poor handling and inadequate cooking. Likely due to development of new pathogen.
- *Mode of Transmission* : Ingestion of contaminated food, especially undercooked beef and raw milk.
- *Symptoms* : Hemolytic uremic syndrome, hemorrhagic colitis.
- *Treatment/Prevention* : Oral or intravenous replacement of fluids.

Legionnaires' Disease (Legionella)

- *Causes of Emergence* : Legionella bacterium widely distributed in environment; found in creeks and ponds, hot and cold water taps, hot water tanks and air-conditioning systems.
- *Mode of Transmission* : Aircooling systems, water supplies.
- *Symptoms* : Fever, headache, confusion, pneumonia.
- *Treatment/Prevention* : Antibiotics such as erythromycin and rifampicin appear to be effective.

Lyme Disease

- *Causes of Emergence* : Increase in deer and human populations in wooded areas.
- *Mode of Transmission* : Bite of infective deer (Ixodes) tick.
- *Symptoms* : Fatigue, headache, rash, fever, arthritis, neurologic and cardiac abnormalities.
- *Treatment/Prevention* : Oral or Intravenous antibiotics.

Streptococcus Infections (Group A)

- *Causes of Emergence* : Change in virulence of the bacteria; possibly mutation.
- *Mode of Transmission* : Direct contact with infected persons or carriers; sometimes ingestion of contaminated foods.
- *Symptoms* : Necrotizing fasciitis, streptococcal toxic shock.
- *Treatment/Prevention* : Antibiotics.

Tuberculosis

- *Causes of Emergence* : Increase in immunosuppressed population, improper treatment exposing more people to disease.
- *Mode of Transmission* : Exposure to sputum droplets exhaled through a cough or sneeze of a person with active disease.
- *Symptoms* : Cough, weight loss, lung lesions; infection can spread beyond lungs to other organs.
- *Treatment/Prevention* : Combination of antibiotics for at least six months.

Typhoid

- *Causes of Emergence* : Spread of typhoid bacillus.
- *Mode of Transmission* : Infected water or milk supplies. Human carriers, particularly food handlers, may be responsible for spread of infection.
- *Symptoms* : Fever, headache, abdominal pain.
- *Treatment/Prevention* : General care, isolation, disinfection of all discharges. Inoculation with vaccine containing killed Salmonella typhi.

REFLECTION OF LIGHT

—Er. D. K. Gupta

Reflection of Light :

The phenomenon of returning back of light in the first medium at the interface of two media is known as reflection of light.

Light moving in one medium when falls at the surface of another medium, part of it returns back in the first medium. Apart from reflection at the interface, part of light gets transmitted in the second medium known as refraction and part of light absorbed at the interface by the second medium.

Mirrors :

A highly polished smooth surface is a mirror. To form a good mirror a thin layer of silver is chemically deposited on a glass surface.

Mirrors may be plane, spherical or paraboidal.

Laws of Reflection :

When a ray of light is incident on a mirror, the point on the mirror where the ray meets the mirror is called the point of incidence. The angle between the incident ray and the normal at the point of incidence is called angle of incidence and the angle between the reflected ray and the normal is called the angle of reflection.

The two laws of reflection are as follows—

(1) The angle of incidence is equal to the angle of reflection.

(2) The incident ray, the normal at the point of incidence and the reflected ray are in the same plane.

Important Observations :

1. The image formed by a plane mirror is virtual and erect when object is real.
2. It is as far behind the mirror as the object is infront of it.
3. It has the same size as the object.
4. The image shows lateral inversion.
   In lateral inversion, the right hand side of the object becomes the left hand side of the image and vice-versa.
5. If the plane mirror is displaced by a distance 'd' from an object, then the image formed by the mirror is displaced by '$2d$' from its previous position.
6. The total number of images of an object formed by two plane mirrors inclined at an angle θ is

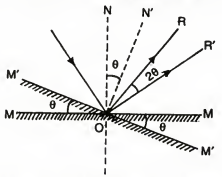
$$n = \left[\frac{360^\circ}{\theta} - 1\right]$$

For $\theta = 60^\circ$, $n = 5$

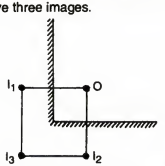
For $\theta = 45^\circ$, $n = 7$

For $\theta = 72^\circ$, $n = 5$

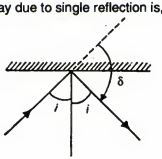
7. If the plane mirror is rotated through an angle θ, the reflected ray rotates through an angle 2θ from its previous position.
   This principle is used in optical levers, sextants etc.



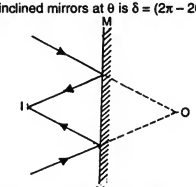
8. If the object is placed between two parallel mirrors, the angle between them being zero, the number of images formed will be equal to ∞.
9. The plane mirrors placed perpendicular to each other will give three images.



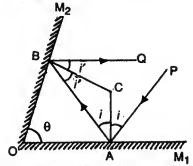
10. If the object moves with speed u towards the mirror then the image also moves with speed u towards the mirror. But the relative velocity of image with respect to object is $2u$.
11. If the object and the mirror move away from each other through a distance d each, then the image moves away through a distance $3d$.
12. Minimum size of the mirror required to see full size image of one self is half the height of the observer.
13. Focal length of the plane mirrors is infinity and its power is zero.
14. A ray of light with the angle of incidence i gets reflected back by an angle of reflection i. So deviation of the ray due to single reflection is, $\delta = (\pi - 2i)$.



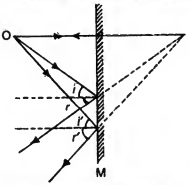
15. Deviation of a ray due to two successive reflections at two inclined mirrors at θ is $\delta = (2\pi - 2\theta)$.



16. When a converging beam of light, whose point of convergence lies behind the mirror, falls on a plane mirror, a real image is formed which can be received on a screen.



17. If after the action of the optical device, the rays appear to diverge from a point, a virtual image is formed. It cannot be obtained on the screen.



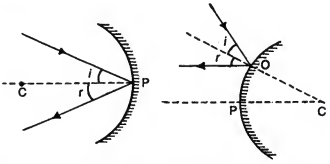
18. When an object is observed through a thick mirror, silvered at its back, a large number of its images are obtained, in which, in general the second image is the brightest. In this case, the first image is formed by the reflection at the first surface, which is unsilvered. The second image is formed after reflection from rear silvered surface, which sends maximum amount of light. Rest of the images formed are due to internal multiple reflections, occurring inside the mirror, which contain less and less amount of light, so their intensity gradually diminishes.

Spherical Mirror :

A spherical mirror is a part of a hollow sphere of glass (or of metal) of which one of the surfaces is polished or silvered. This polished or silvered surface of the sphere reflects the light in a regular manner.

Concave mirror—In a concave mirror reflection takes place from the hollow side.

Convex mirror—In a convex mirror reflection takes place from the outer surface.



Common Terms Used in Spherical Mirrors :

(1) **Pole**—The mid point of the curved spherical surface is the pole of the mirror.

(2) **Centre of the curvature**—It is the centre of the sphere of which the mirror is a part.

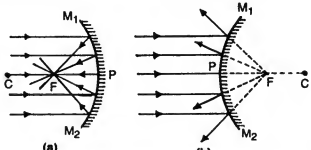
(3) **Radius of Curvature**—It is the radius of the sphere of which the mirror forms a part. It is equal to the distance between the pole (P) and centre of curvature (C) of the mirror.

(4) **Principal axis**—It is the straight line passing through the pole and the centre of curvature of the mirror.

(5) **Aperture**—The diameter of the circle formed of the periphery of the curved mirror is the linear aperture of the mirror.

(6) **Angular aperture**—It is the angle formed by the two ends of a diameter of the peripheral circle, at the centre of curvature of the spherical mirror.

(7) **Focal point or Focus**—When a parallel beam of light is incident on a spherical mirror parallel to its principal axis, the reflected beam either converges to (as in a concave mirror) or appears to diverge from (as in a convex mirror) a point on the principal axis. This point is known as the focal point or the focus of the mirror.



(8) **Focal length**—The distance between the pole and the focal point of the spherical mirror is known as focal length (f).

$$\text{Focal length } (f) = \frac{\text{Radius of curvature } (r)}{2}$$

(9) **Focal plane**—A plane passing through focus and perpendicular to the principal axis is the focal plane of the spherical mirror.

Sign Convention

1. The light rays are allowed to be incident from the left.
2. All the distances are measured from the pole of the mirror along the principal axis.
3. The distances measured in the direction of incident light are taken positive.
4. The distances measured in the direction opposite to the direction of the incident light are taken negative.
5. The distances measured above the principal axis are taken positive and below the axis as negative.

According to this sign convention the focal length of a convex mirror is taken positive and that of a concave mirror is taken as negative. Magnification is positive for erect images and negative for inverted images.

Spherical Mirror Formula :

The algebraic relationship for all spherical mirrors is

$$\frac{1}{u}+\frac{1}{v}=\frac{2}{r}=\frac{1}{f}$$

where u is the distance of the object.

v is the distance of the image.

r is the radius of curvature.

f is the focal length.

Magnification :

(1) Linear or Transverse magnification—

$$M = \frac{\text{Linear size of the image}}{\text{Linear size of the object}}$$

$$M = -\frac{v}{u} = -\frac{f}{u-f}$$

And,

$$M = -\frac{v-f}{f}$$

(2) Axial or Longitudinal magnification—

$$M_{axial} = \frac{dv}{du} = \frac{v^2}{u^2}$$

$$M_{axial} = \left(\frac{v-f}{f}\right)^2 = \left(\frac{f}{u-f}\right)^2$$

(3) Angular magnification—

$$M_{angular} = \frac{\text{Angle subtended by the image at the pole of the mirror}}{\text{Angle subtended by the object at the pole of the mirror}}$$

Also,

$$M_{angular} = \frac{\text{Angle made by the reflected ray with the principal axis}}{\text{Angle made by the incident ray with the principal axis}}$$

Relation between these magnifications :

$$M_{linear} = M_{axial} \times M_{angular}$$

Identification of mirrors on the basis of images formed :

Nature of image of real object	Mirror
(1) Virtual, erect, same size	Plane
(2) Virtual, erect, diminished	Convex
(3) Virtual, erect, magnified	Concave
(4) Real, inverted, magnified or diminished	Concave

Newton's Formula

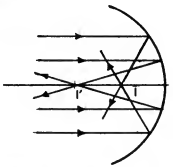
If the distances of the object and the image, measured from focal point, are x and y respectively then

$$xy = f^2$$

Spherical Aberration :

The light ray from a point incident at different distances from the axis of a spherical mirror (*i.e.*, marginal and paraxial rays) after reflection from the mirror do not converge to (or appear to diverge from) a single point.

Marginal rays deviate more by reflection while paraxial rays deviate less. Thus instead of a point image, a blurred image is formed. This defect of image, is called spherical aberration. To remove spherical aberration from mirrors paraboidal mirrors are used.



Uses of Mirrors

1. Plane mirror is used in dressing tables. The image is erect, virtual and of the same size as the object.
2. It is used as a looking glass.
3. A concave mirror is used as shaving glass. When the face is held between focus and pole of the mirror, a magnified erect image is formed.
4. Concave mirror is used as a reflector for the head lights of motor cars, cycles and search lights etc.
5. A concave mirror is used in opthalmoscope for examining eye, ear etc. by doctors.
6. A concave mirror is used as objective in reflecting telescope.
7. A concave mirror is also used for concentrating the radiant energy of the sun at its focus. In this way fire can also be produced.
8. A convex mirror is used as view finder in car etc. as it provides the maximum rear field of view. It is also used as reflector in street lightening.

SOME IMPORTANT SOLVED EXAMPLES

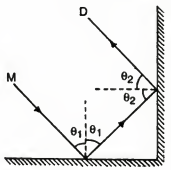
Example 1. Calculate the angle between two plane mirrors, if a ray after successive reflections from them becomes parallel to itself.

Solution :

Since the ray after successive reflection becomes parallel to itself, hence

$$180° - 2\theta_1 + 180° - 2\theta_2 = 180°$$

or, $$\theta_1 + \theta_2 = 90°$$



$\therefore$ Angle between mirrors

$$= 180 - [(90° - \theta_1) + (90° - \theta_2)]$$
$$= \theta_1 + \theta_2$$
$$= 90°$$

Short Method :

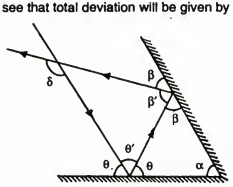
If θ is the angle between mirrors, total deviation produced is $360° - 2\theta$. This must be $180°$ since incident and final reflected rays are parallel.

$$360° - 2\theta = 180°$$
$\therefore$ $$2\theta = 180°$$
or, $$\theta = 90°$$

Example 2. Two plane mirrors are inclined at angle α. A ray of light falls on one of them making an angle θ with its surface, what is the total deviation suffered by the ray if it is reflected once by each mirror ?

Solution :

We see that total deviation will be given by



$$\delta = \beta' + \theta' = (180° - 2\beta) + (180° - 2\theta)$$
$$= 360° - 2(\beta + \theta)$$
$$\delta = 360° - 2(180° - \alpha)$$

or, $$\delta = 360° - 360 + 2\alpha$$
or, $$\delta = 2\alpha$$

Example 3. A shaving mirror produces an erect image of a man's face 3 times its actual size, when the face is 30 cm infront of it. Find (a) whether the mirror is concave or convex; (b) what is its radius of curvature ?

Solution :

(a) The image has a magnification greater than 1 and it is erect. In case of convex mirror the magnification is always less than 1, therefore, the mirror is concave. A concave mirror gives an erect, enlarged virtual image, if the object distance is, less than its focal length.

(b) $m = 3$ for erect image

$\therefore$ $$\frac{v}{u} = 3 \text{ (numerically)}$$

$$v = 3u = 3 \times 30$$
$$= 90 \text{ cm}$$

For virtual image formation by a concave mirror

$$u = -30 \text{ cm}, v = 90 \text{ cm}, f = ?$$

$$\frac{1}{f} = \frac{1}{90} - \frac{1}{30}$$
$$= \frac{-2}{90}$$

$\Rightarrow$ $$f = -45 \text{ cm}$$

$\therefore$ Radius of curvature $= 2 \times 45$
$= 90$ cm

Second Method :

For a concave mirror forming virtual image

$$-\frac{1}{u} + \frac{1}{v} = -\frac{1}{f}$$
$$-1 + \frac{u}{v} = -\frac{u}{f}$$
$$-1 + \frac{1}{m} = -\frac{u}{f}$$
$$\frac{u}{f} = 1 - \frac{1}{m}$$
$$= 1 - \frac{1}{3} = \frac{2}{3}$$
$$f = \frac{3 \times 30}{2}$$
$$= 45 \text{ cm}$$
$\therefore$ $$r = 2f = 2 \times 45$$
$$= 90 \text{ cm}$$

Example 4. How far away from a concave mirror of focal length 30 cm focal length should a real object be located in order that its image be one fourth of its actual size ?

Solution :

A concave mirror forms a diminished real image of an object if it is beyond 2F.

Here $m = \frac{v}{u} = \frac{1}{4}$

$$\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$$

$$1 + \frac{u}{v} = \frac{u}{f}$$

or, $$1 + \frac{1}{m} = \frac{u}{f}$$

or, $$\frac{u}{30} = \frac{(1+m)}{m}$$

or, $$u = \frac{30\left(1+\frac{1}{4}\right)}{\frac{1}{4}}$$

$$= 150 \text{ cm}$$

Example 5. A concave mirror has a radius of curvature of 50 cm. What are the two positions at which an object may be placed in order to give an image four times as large ?

Solution :

Here $\frac{v}{u} = 4$

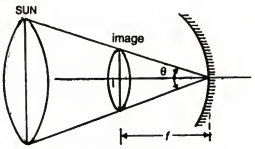
or, $v = 4u$

Two positions of object correspond to real and virtual image respectively.

For real image	**For virtual image**
$u = -x$ and $v = -4x$	$u = -y$ and $v = +4y$
$\therefore \frac{1}{-4x} + \frac{1}{-x} = \frac{1}{-\frac{50}{2}}$	$\therefore \frac{1}{+4y} + \frac{1}{-y} = \frac{1}{-\frac{50}{2}}$
or, $\frac{5}{-4x} = \frac{2}{-50}$	or, $\frac{-3}{4y} = \frac{2}{-50}$
$\therefore x = \frac{5 \times 50}{8}$ cm	$\therefore y = \frac{3 \times 50}{8}$ cm
or, $x = 31{\cdot}25$ cm	or, $y = 18{\cdot}75$ cm

Example 6. The sun makes an angle of 0·54° at the pole of a concave mirror of radius of curvature 2m. What will be the size of its image ?

Solution :



Focal length of the mirror $= f = \frac{r}{2}$

$= 1$ m

$= 100$ cm

Image is formed at the focus and its diameter subtends the same angle at the pole as the sun.

Diameter of the image $= D = \theta \times \frac{r}{2}$

$= \theta \cdot f$

where θ is in radian.

$\therefore D = \left[\frac{0{\cdot}54 \times \pi}{180}\right] \times 100$ cm

$\approx 0{\cdot}94$ cm

Note—Diameter of the image

$$= \frac{\text{Sun's diameter} \times f}{\text{Distance of sun from earth}}$$

or, $$\boxed{D = \frac{\theta \times f \times \pi}{180}}$$

QUESTIONS FROM DIFFERENT COMPETITIVE EXAMINATIONS

1. A light bulb is placed between two plane mirrors inclined at an angle of 60°. The number of images formed are—
   (A) 6 (B) 2
   (C) 5 (D) 4
   (NCERT, 1980)

2. It is desired to photograph the image of an object placed at a distance 3m from the plane mirror. The camera, which is at a distance of 4·5 m from the mirror should be focussed for a distance of—
   (A) 3 m (B) 4·5 m
   (C) 6 m (D) 7·5 m
   (NCERT, 1971)

3. At sun rise or sun set, the sun looks reddish because—
   (A) The sun is coldest at these times
   (B) Of the effects of reflection and refraction
   (C) The sun is hottest at these times
   (D) Of the scattering of light
   (CET, 1991)

4. When a plane mirror is placed horizontally on level ground at a distance of 60 metres from the foot of a tower, the top of the tower and its image in the mirror subtend at the eye an angle of 90°. The height of the tower is—
   (A) 30 metre
   (B) 60 metre
   (C) 90 metre
   (D) 120 metre
   (CPMT, 1984)

5. All of the following statements are correct except—
   (A) The magnification produced by a convex mirror is always less than one
   (B) A virtual, erect, same sized image can be obtained by using a plane mirror
   (C) A virtual, erect, magnified image can be formed using a concave mirror
   (D) A real, inverted, same sized image can be formed using a convex mirror
   (Manipal, 1995)

6. A pencil of light is incident on a plane mirror and after being deflected from it, forms a real image. Then the pencil of light incident on the mirror is—
   (A) Parallel
   (B) Divergent
   (C) Convergent
   (D) Statement is wrong
   (MP. PMT, 1997)

7. A plane mirror produces a magnification of—
   (A) –1
   (B) + 1
   (C) Zero
   (D) Between 0 and + ∞
   (MP. PMT, 1998)

8. An object is placed at a distance of 40 cm in front of a concave mirror of focal length 20 cm. The image produced is—
   (A) Virtual and inverted
   (B) Real and erect
   (C) Real, inverted and diminished
   (D) Real, inverted and of the same size as the object
   (MP. PMT, 1998)

9. A luminous object is placed at a distance of 30 cm from the convex lens of focal length 20 cm. On the other side of the lens, at what distance from the lens a convex mirror of radius of curvature 10 cm be placed in order to have an upright image of the object coincidental with it ?
   (A) 12 cm (B) 30 cm
   (C) 50 cm (D) 60 cm
   (CBSE, 1998)

ANSWERS

1. (C) 2. (D) 3. (D) 4. (B) 5. (D)
6. (C) 7. (B) 8. (D) 9. (C)

HINTS

1. Number of images $n = \frac{360}{\theta} - 1$

   Here $\theta = 60°$

   Hence $n = \frac{360}{60} - 1$

   $= 5$

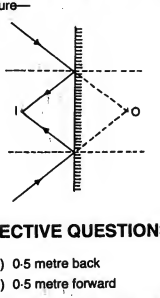
2. The image is as far behind the mirror as the object is infront of it. Hence distance of the image from the camera

   $= 4{\cdot}5 + 3$

   $= 7{\cdot}5$ m

4. The angle subtended at the eye by the top of the tower with respect to ground is 45°. This happens when the height of the tower is equal to its distance from the eye. The eye is assumed to be very near to the mirror.

6. When a convergent beam of light, converging at O, is incident on a plane mirror, a real image is formed at I as shown in the figure—



8. $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$

   $\frac{1}{v} - \frac{1}{40} = \frac{1}{-20}$

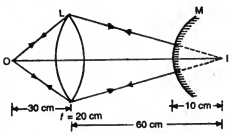
   $\frac{1}{v} = -\frac{1}{20} + \frac{1}{40}$

   $= -\frac{1}{40}$

   or, $v = -40$ cm

   Therefore, the image is formed at centre of curvature. So it is real, inverted and of the same size as the object.

9.



   For refraction through a convex lens

   $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

   $\frac{1}{v} - \frac{1}{-30} = \frac{1}{20}$

   $\therefore \quad v = 60$ cm

   Coincidence is possible when the image is formed at the centre of curvature of the mirror. Only then the rays refracting through the lens will fall normally on the convex mirror and retrace their path to form image at O. So the distance between lens and mirror

   $= 60 - 10$

   $= 50$ cm

OBJECTIVE QUESTIONS

1. The two adjacent walls and the ceiling of a room are mirrored. The number of images formed of an object inside the room will be—
   (A) 9 (B) 7
   (C) 5 (D) 3

2. A plane mirror which is at first 1 metre from an object, is then moved back 0·5 metre parallel to itself. The image will then move from its position—
   (A) 1 metre back
   (B) 1 metre forward
   (C) 0·5 metre back
   (D) 0·5 metre forward

3. When an object is moving away with a speed of 5 cm/sec from a mirror, its image will move away from the mirror with a speed of—
   (A) 10 cm/sec (B) 15 cm/sec
   (C) 5 cm/sec (D) 2·5 cm/sec

4. Number of images formed in two mirrors parallel to each other are—
   (A) Zero (B) 2
   (C) Infinite (D) 5

5. A thick mirror produces a number of images of the object. Which image is the brightest ?
   (A) First (B) Second
   (C) Third (D) Last one

6. Two mirrors inclined to each other produce five images of an object placed between them. If the angle between them is reduced by 30°, what will be the number of images seen in the two mirrors ?
   (A) 15 (B) 12
   (C) 13 (D) 11

7. If x and y be the distance of the object and image formed by a concave mirror from its focus and f be the focal length, then—
(A) $xy = f$ (B) $xy = f^2$
(C) $\frac{x}{y} = f$ (D) $\frac{x}{y} = f^2$

8. A ray of light making an angle 10° with the horizontal is incident on a plane mirror making angle θ with the horizontal. What should be the value of θ so that the reflected ray goes vertically upward ?
(A) 30° (B) 40°
(C) 50° (D) 60°

9. A small plane mirror is placed at the centre of a spherical screen of radius r. A beam of light is incident on the mirror. If the mirror makes n revolutions per second, what will be the speed of the reflected light spot on the screen ?
(A) πnr (B) $2\pi nr$
(C) $3\pi nr$ (D) $4\pi nr$

10. A ray of light making an angle 20° with the horizontal is incident on a plane mirror, which itself is inclined to the horizontal at an angle 10°, with the normal away from the incident ray. What is the angle made by the reflected ray with the horizontal ?
(A) 10°
(B) 20°
(C) 30°
(D) None of the above

11. The angle between the incident ray and the reflected ray from a plane mirror is 60°. Through what angle is the reflected ray deviate with respect to the incident ray ?
(A) 150° (B) 120°
(C) 90° (D) 60°

12. Which type of mirror always forms a diminished and virtual image of the real object ?
(A) Convex (B) Concave
(C) Plane (D) Parabolic

13. A concave mirror forms the real image of an object which is magnified 4 times. The object is moved 3 cm away, the magnification of the image is 3 times. What is the focal length of the mirror ?
(A) 3 cm (B) 4 cm
(C) 12 cm (D) 36 cm

14. For a man 1·6 metre tall, the minimum size of the mirror to look his image completely should be—
(A) 1·6 m (B) 0·8 m
(C) 3·2 m (D) 1·2 m

15. Two mirrors are inclined at an angle θ. A ray of light strikes the first mirror, parallel to the second mirror, then goes to second mirror and returns finally parallel to the first mirror. The value of θ will be—
(A) 30° (B) 60°
(C) 45° (D) 90°

16. For shaving purpose, the best result obtained will be, by a—
(A) Plane mirror
(B) Convex mirror
(C) Concave mirror
(D) Half mirror

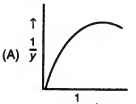
17. A concave mirror of focal length f produces an image n times the size of the object. If the image is real then the distance of the object from the mirror is—
(A) $(n-1)f$ (B) $\left(\frac{n-1}{n}\right)f$
(C) $\left(\frac{n+1}{n}\right)f$ (D) $(n+1)f$

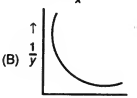
18. The field of view is maximum for—
(A) Plane mirror
(B) Concave mirror
(C) Convex mirror
(D) Cylindrical mirror

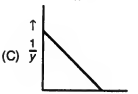
19. While using an electric bulb the reflection for street lighting should be—
(A) Concave mirror
(B) Convex mirror
(C) Cylindrical mirror
(D) Paraboloidal mirror

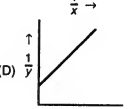
20. The largest distance of the image from a convex mirror of focal length 10 cm can be—
(A) 30 cm
(B) Infinite
(C) 10 cm
(D) Depends on the position of the object

21. An object is placed at a distance x cm from a concave mirror of focal length 2 cm. The real image of the object is received on a screen placed at a distance of y cm from the mirror. The values of x are changed and the corresponding values of y are measured. Which one of the graphs shown in the figure represents the variation of $\frac{1}{y}$ with $\frac{1}{x}$?

(A)


(B)


(C)


(D)


22. The diameter of the moon is about 3500 km. What will be the diameter of the image formed by a concave mirror of radius 3 m ? Assume that the distance of the moon is about $3{\cdot}5 \times 10^5$ km—
(A) 5 mm (B) 10 mm
(C) 15 mm (D) 20 mm

23. A spherical mirror forms an erect image three times the linear size of the object. If the distance between the object and the image is 100 cm, the focal length of the mirror is—
(A) 15 cm (B) 25 cm
(C) 37·5 cm (D) 50 cm

24. A concave mirror and a convex lens have the same focal length in air. When submerged in water–
(A) The concave mirror would have a greater focal length
(B) The convex lens would have a greater focal length
(C) They would have the same focal length but different from that in air
(D) They would have the same focal length as in the air

25. Which one of the following optical components form a perfect image free from all aberrations ?
(A) A plane mirror
(B) A spherical mirror
(C) A spherical lens
(D) A cylindrical lens

26. A virtual image larger than object can be produced by—
(A) Concave mirror
(B) Convex mirror
(C) Plane mirror
(D) Concave lens

27. A concave mirror of focal length f in air is used in a medium of refractive index 2. What will be the focal length of the mirror in the medium ?
(A) $4f$
(B) $2f$
(C) $\frac{f}{2}$
(D) None of the above

28. Which one of the following is not the case with the image formed by a concave mirror ?
(A) It may be erect or inverted
(B) It may be magnified or diminished
(C) It may be real or virtual
(D) Real image may be between pole and focus or beyond focus

29. A man runs towards a plane mirror at 2 m/s. The relative speed of his image *w.r.t.* him will be—
(A) 2 m/s
(B) 4 m/s
(C) 8 m/s
(D) 10 m/s

30. Which one of the following is not the case with the image formed by a convex mirror ?
(A) It is erect
(B) It is virtual
(C) It is diminished
(D) It lies beyond the focus

31. An object is placed at the focus of convex mirror. If the focal length of the mirror be f, then the distance of the image from the pole of the mirror is—
(A) Less than f
(B) Equal to f
(C) More than f
(D) Infinity

32. An object is placed at the focus of a concave mirror. If the focal length of the mirror be 20 cm. then the distance of the image from the pole of the mirror is—
(A) 10 cm (B) 20 cm
(C) 40 cm (D) Infinity

ANSWERS

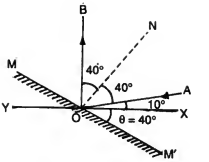
1. (B) 2. (A) 3. (C) 4. (C) 5. (B)
6. (D) 7. (B) 8. (B) 9. (D) 10. (D)
11. (B) 12. (A) 13. (D) 14. (B) 15. (B)
16. (C) 17. (C) 18. (C) 19. (B) 20. (C)
21. (C) 22. (C) 23. (C) 24. (B) 25. (A)
26. (A) 27. (D) 28. (D) 29. (B) 30. (D)
31. (A) 32. (D)

HINTS

1. The number of images formed by two adjacent wall will be three, taking $\theta = 90°$. Further images formed of these three images by the ceiling will be again three. There will be one direct image of the object formed by the ceiling. So the total no. of images will be $3 + 3 + 1 = 7$.

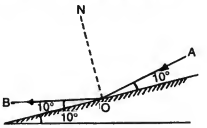
6. For 5 images, $\theta = 60°$
Therefore the number of images at $\theta = 60° - 30° = 30°$ will be
$$\left(\frac{360}{30} - 1\right) = 11$$

7. We have $m = \frac{f}{f-u}$
$= \frac{f-v}{f}$
or, $\frac{f}{x} = \frac{y}{f}$
or, $f^2 = xy$

8. 

Here XY is horizontal line.
AO is incident ray and OB is reflected ray.

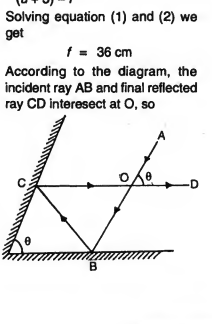
9. The reflected ray turns through angle 2θ, when the mirror is turned through angle θ. Hence rotational speed of the light spot will be $2n$ revolutions per second.

10. 

Here AO is incident ray, OB is the reflected ray.
The reflected ray goes along the horizontal. Hence ang'ɜ made by the reflected ray with the horizontal is zero.

11. $\delta = 180 - 2i$
Here $i = 30°$
$\therefore \quad \delta = 180 - 2 \times 30°$
$= 120°$

13. In the 1st case
$$m = \frac{f}{u-f} = 4 \quad ...(1)$$
In the 2nd case
$$\frac{f}{(u+3)-f} = 3 \quad ...(2)$$
Solving equation (1) and (2) we get
$f = 36$ cm

15. According to the diagram, the incident ray AB and final reflected ray CD interesect at O, so


$\angle AOD = \angle COB$

$= \theta$

The deviation of the ray according to the diagram

$\delta = \pi + \theta$

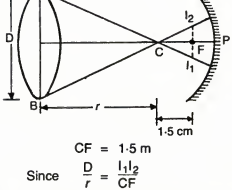
But $\delta = 2\pi - 2\theta$

$\therefore \quad 2\pi - 2\theta = \pi + \theta$

or, $\theta = \frac{\pi}{3} = 60°$

22. Here $D = 3500$ km

$r = 3{\cdot}5 \times 10^5$ km



$CF = 1{\cdot}5$ m

Since $\frac{D}{r} = \frac{I_1I_2}{CF}$

(From similar triangles as Δ ABC and Δ CI_1I_2)

$\therefore \quad I_1I_2 = \frac{CFD}{r}$

$= 15$ mm

23. $m = \frac{v}{u} = 3$

or, $v = 3u$

Given that $u + v = 100$

$\therefore \quad u + 3u = 100$

or, $u = 25$ cm

and $v = 75$ cm

Here since the image is erect, therefore, the image must be virtual.

$\therefore \quad u = -25$ cm

$v = 75$ cm

Now using $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$

$\frac{1}{75} - \frac{1}{25} = \frac{1}{f}$

$\therefore \quad f = -37{\cdot}5$ cm

Mirror is concave.

24. $\frac{1}{f} = \left(\frac{\mu_2 - \mu_1}{\mu_1}\right)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$

Here μ_2 is the refractive index of lens and μ_1 is that of medium. Since μ_1 is less than that of glass (μ_2), hence the focal length of lens increases in water. But the focal length of mirror remains unchanged.

27. Focal length of mirror does not depend on the medium from which the light is incident. It will continue to be f.

28. Real image cannot lie between pole and focus.

●●●

X-RAYS

Discovery of X-rays :

X-rays were discovered in 1895 by a German physicist W. C. Roentgen who was honoured with nobel prize for it.

When highly energetic electrons are made to strike a metal target of high atomic weight and high melting point, electromagnetic radiation comes out. A large part of this radiation has wavelength of the order of 0·1 nm (≈ 1Å) and is known as X-rays.

Production of X-rays :

Now-a-days X-rays are produced by coolidge tube which was originally designed by Dr. Coolidge in 1913. It has a filament and a metallic target fixed in an evacuated hard glass chamber. The filament is heated electrically and emits electrons by thermionic emission. A constant potential difference of several kilovolts is maintained between the filament and the target.

The electrons emitted by the filament are accelerated between the filament and the target and hit the target with a very high speed. These electrons are stopped by the target and in the process X-rays are emitted which are brought out through a window.

In the process of production of X-rays, due to continuous striking of the electrons with the target, large amount of heat is developed (Actually only about 0·2% energy of electrons is utilised for the production of X-rays, the rest is converted into heat). This heat is removed by continuously running cold water.

Control of Intensity of X-rays :

Intensity of X-rays depends upon the number of electrons emitted and striking the target per second. Thus, to increase the intensity of X-rays, the current through the filament is increased.

Control of Penetrating Power of X-rays :

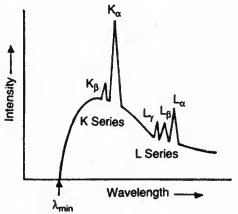
The penetrating power of X-rays depends on their wavelength. The X-rays of shorter wavelength (≈ 1Å) have higher energy and are, therefore, more penetrating. These are called **'hard' X-rays**. The X-rays of longer wavelength (≈ 4Å) have smaller energy. Hence, they are less penetrating. These are called **'soft' X-rays**.

The wavelength of X-rays depends upon the kinetic energy of electrons which in turn depends on the potential difference across the tube. As the potential difference is increased, the wavelength of X-rays produced decreases *i.e.*, their penetrating power increases. Hence, the penetrating power of X-rays can be increased or decreased by increasing or decreasing the potential difference across the tube.

Note—The intensity and the penetrating power of X-rays can be controlled independently in a coolidge tube.

Spectrum of X-rays :

If the X-rays coming from a coolidge tube are examined for wavelengths present and the intensity of different wavelength components are measured, we obtain a plot of the nature shown in the figure. We see that there is a minimum wavelength below which no X-ray is emitted. This is called **cut off wavelength** or **threshold wavelength**.



The X-rays emitted can be clearly divided in two categories. At certain sharply defined wavelengths, the intensity of X-rays is very large as marked K_α, K_β in the figure. These X-rays are known as **characteristic X-rays**. At other wavelengths the intensity varies gradually so that no definite line of separation can be drawn between any two of them. These X-rays are called **continuous X-rays**.

Explanation of Continuous X-rays :

Suppose the potential difference applied between the target and the filament is V and that electrons are emitted by the filament with negligible speed. The kinetic energy of the electron when it hits the target is K = eV.

The electron on entering into the target, makes several collisions with the atoms in the target, losing its kinetic energy at each collision before coming to rest.

When the kinetic energy of the electron is reduced in a collision, a part of the lost kinetic energy is converted into a photon of electromagnetic radiation and the remaining part increases the kinetic energy of the colliding particle of the target which produces heating of the target.

The fraction of kinetic energy appearing as the energy of a photon varies from collision to collision. In a certain collision, the electron may lose its entire kinetic energy to bring out a photon or it may not create a photon at all. Thus, the energy of the photon created can be

anything between 0 and eV depending on how much energy has already been lost to the target and what fraction of the available energy is converted into the photon. The maximum energy of such a photon can be E = eV when the electron converts all its kinetic energy into a photon in the first collision itself.

The wavelength of the X-rays and the energy of the corresponding photon are related as

$$E = h\upsilon = \frac{hc}{\lambda}$$

or, $$\lambda = \frac{hc}{E}$$

As E can take any value between 0 and eV, the wavelength λ can take any value between infinity and $\frac{hc}{eV}$. This explains the origin of continuous X-rays and cut off wavelength. We have

$$\lambda_{min} = \frac{hc}{eV}$$

Note that the cut off wavelength λ_{min} depends only on the accelerating voltage V applied between the filament and the target. It does not depend on the material of the target.

Substituting

$h = 6{\cdot}6 \times 10^{-34}$ joule-second,

$c = 3 \times 10^{8}$ ms^{-1}

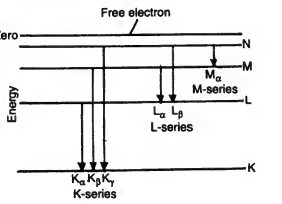
and $e = 1{\cdot}6 \times 10^{-19}$ coulomb,

we get $$\lambda_{min} = \frac{1{\cdot}2375 \times 10^{-6}}{V} \text{ m}$$

$$= \frac{12375}{V} \text{ Å}$$

Explanation of Characteristic X-rays :

Characteristic X-rays are produced when an electron knocks out an inner electron from the atom with which it collides. The lines of characteristic spectrum are produced only when materials are bombarded by high energy electron beams which are able to penetrate deep into atoms and displace electrons from very 'deep' energy levels. The subsequent fall of an electron from a higher level into one of these gaps causes the emission of a high energy X-ray photon.

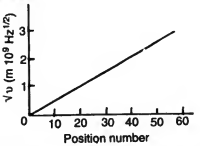


The K-series of X-ray lines is produced when an electron is knocked out of the lowest or the K-shell. The fall of an electron from other shells into the gap in the K-shell causes the emission of a line of the K-series. If the electron falls from L-shell, the K_α line occurs; when from M-shell, we have K_β line and so on.

Similarly the L-series arises when the electrons fall into the vacancies of the L-shell. This series is excited by small energies than the K-series because the L-electrons are less strongly held, the X-rays emitted have lower frequencies and longer wavelengths and are less penetrating.

Moseley's Law :

Moseley measured the frequencies of the characteristic X-rays from a large number of elements and plotted the square root of the frequency against its position number in the periodic table (in earlier periodic table the elements were arranged in the increasing order of atomic weight). He discovered that the plot is very close to a straight line.



A portion of Moseley's plot is shown in the figure, where $\sqrt{\upsilon}$ of K_α X-rays is plotted against the position number. From this linear relation Moseley concluded that there must be a fundamental property of the atom which increases by regular steps as one moves from one element to the other. This quantity was later identified to be the number of protons in the nucleus and was referred to as the **atomic number**.

Thus, the elements should be arranged in ascending order of atomic number and not of atomic weight.

Moseley's observation can be mathematically expressed as

$$\sqrt{\upsilon} = a\,(Z - b)$$

where *a* is the constant of proportionality and *b* is the screening constant. This relation is known as Moseley's law.

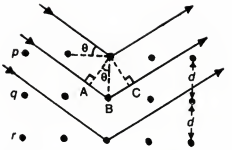
Bragg's Law of X-ray diffraction :

X-rays are electromagnetic waves of short wavelengths and may be diffracted by suitable diffracting centres. To have appreciable diffraction effects the aperture should be of the order of wavelength *i.e.*, of the order of 0·1 nm. Nature has provided us with such apertures in the form of crystals. In a solid the atoms are arranged in parallel planes separated by a distance *d*.

Suppose an X-ray beam is incident on a solid, making an angle θ with the planes of the atoms. These X-rays are diffracted by different atoms and the diffracted beams interfere and the resultant reflected beam is strong only if the path difference between successive planes is a whole number of wavelengths of the incident X-radiation.

Thus, reinforcement occurs for plane *p* and *q* only when

$$AB + BC = n\lambda$$



where n is an integer and λ is the wavelength of the X-rays. Now d is the distance between the planes of atoms and θ is the angle between the X-ray beam and the crystal surface, called the grazing angle, clearly

$$AB + BC = 2d \sin \theta$$

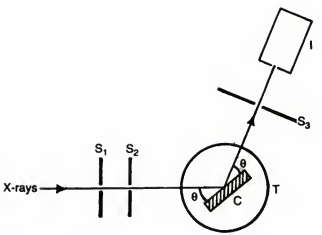
Hence, $2d \sin \theta = n\lambda$

This equation is known as **Bragg's law.**

Bragg Spectrometer :

The Bragg X-ray spectrometer was developed to measure (*i*) X-ray wavelengths and (*ii*) the spacings of atoms in crystals. The plan of the instrument is shown in the figure.

X-rays from the target of an X-ray tube are collimated by two slits S_1 and S_2 (made in lead sheets) and the narrow beam so formed falls on a crystal C set on the table T of the spectrometer. The reflected beam passes through a third slit S_3 into an ionisation chamber I where it produces an ionisation current which is a measure of the intensity of the reflected radiation.



As the crystal and the ionisation chamber are rotated. The angle of reflection always being kept equal to the angle of incidence, the ionisation current is found. Strong reflection occurs for glancing angles satisfying Bragg's law

$$2d \sin \theta = n\lambda$$

Knowing either d or λ, the other can be calculated.

SOME IMPORTANT SOLVED EXAMPLES

Example 1. An X-ray tube operates at 30 kV and the current through it is 2·0 mA. Calculate—

(I) The electrical power input

(II) The number of electrons striking the target per second.

(III) The speed of electrons when they hit the target.

(Iv) The lower wavelength limit of the X-rays emitted.

Solution :

(i) Power input $= VI$

$= (30 \times 10^3) \times (2{\cdot}0 \times 10^{-3}) = 60$ W

(ii) The number n of electron striking the target per second is given by

$$n = \frac{I}{e} = \frac{2{\cdot}0 \times 10^{-3}}{1{\cdot}6 \times 10^{-19}}$$

$$= 1{\cdot}25 \times 10^{16}$$

(iii) $\frac{1}{2} mv^2 = eV$

$$v = \sqrt{\frac{2eV}{m}}$$

$$= \sqrt{\frac{2 \times 1{\cdot}6 \times 10^{-19} \times 30 \times 10^3}{9{\cdot}0 \times 10^{-31}}}$$

$$= 1{\cdot}0 \times 10^8 \text{ ms}^{-1}$$

(iv) $\lambda_{min} = \frac{hc}{eV} = \frac{6{\cdot}6 \times 10^{-34} \times 3 \times 10^8}{1{\cdot}6 \times 10^{-19} \times 30 \times 10^3}$

$$= 0{\cdot}41 \times 10^{-10} \text{ m} = 0{\cdot}41 \text{ Å}$$

Example 2. Find the maximum frequency of the X-rays emitted by X-ray tube operating at 30 kV.

Solution :

$$h\upsilon_{max} = eV$$

$$\upsilon_{max} = \frac{eV}{h} = \frac{1{\cdot}6 \times 10^{-19} \times 30 \times 10^3}{6{\cdot}6 \times 10^{-34}}$$

$$= 7{\cdot}2 \times 10^{18} \text{ Hz}$$

Example 3. An X-ray tube operates at 20 kV. A particular electron loses 5% of its kinetic energy to emit an X-ray photon at the first collision. Find the wavelength corresponding to this photon.

Solution :

Kinetic energy acquired by the electron is

$$K = eV$$

$$= 20 \times 10^3 \text{ eV}$$

The energy of the photon

$$= \frac{5}{100} \times 20 \times 10^3$$

$$= 10^3 \text{ eV}$$

Now, $h\upsilon = \frac{hc}{\lambda} = 10^3$ eV

$$\lambda = \frac{hc}{10^3\ eV}$$
$$= \frac{6{\cdot}6 \times 10^{-34} \times 3 \times 10^8}{10^3 \times 1{\cdot}6 \times 10^{-19}}$$
$$= 1{\cdot}24 \times 10^{-9}\ m$$
$$= 1{\cdot}24\ nm$$

Example 4. The K_α X-ray of molybdenum has wavelength 71 pm. If the energy of a molybdenum atom with a K-electron knocked out is 23·32 keV, what will be the energy of this atom when an L electron is knocked out ?

Solution :

K_α X-ray results from the transition of an electron from L shell to K shell. If the energy of the atom with a vacancy in the K shell is E_K and the energy with a vacancy in the L shell is E_L, the energy of the emitted photon is $E_K - E_L$. The energy of the 71 pm photon is

$$E = \frac{hc}{\lambda}$$
$$= \frac{6{\cdot}6 \times 10^{-34} \times 3 \times 10^8}{71 \times 10^{-12}}\ J$$
$$= \frac{6{\cdot}6 \times 10^{-34} \times 3 \times 10^8}{71 \times 10^{-12}} \times \frac{1}{1{\cdot}6 \times 10^{-19} \times 10^3}\ k\ eV$$
$$= 17{\cdot}4\ k\ eV$$

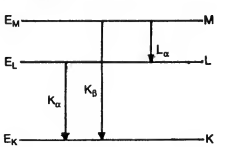
Now $E_K - E_L = 17{\cdot}4\ k\ eV$

$\therefore$ $E_L = E_K - 17{\cdot}4$
$= 23{\cdot}32 - 17{\cdot}4$
$= 5{\cdot}92\ keV$

Example 5. Show that the frequencies of K_β X-ray of a material equals the sum of the frequencies of K_α and L_α X-rays of the same material.

Solution :

From the energy level diagram of an atom with one electron knocked out



$$E_{k_\alpha} = E_L - E_K$$
$$E_{k_\beta} = E_M - E_K$$
and $E_{L_\alpha} = E_M - E_L$
Thus, $E_{K_\beta} = E_{k_\alpha} + E_{L_\alpha}$
$$h\upsilon_{k_\beta} = h\upsilon_{k_\alpha} + h\upsilon_{L_\alpha}$$
or, $$\upsilon_{k_\beta} = \upsilon_{k_\alpha} + \upsilon_{L_\alpha}$$

Example 6. What element has K_α line of wavelength 1·785 Å ?

R = 109737 cm^{-1}

Solution :

$$\frac{1}{\lambda} = R(Z-1)^2\left[\frac{1}{1^2} - \frac{1}{2^2}\right]$$
$$(Z-1)^2 = \frac{4}{3} \cdot \frac{1}{\lambda} \cdot \frac{1}{R}$$
$$= \frac{4}{3} \times \frac{1}{1{\cdot}785 \times 10^{-8}} \times \frac{1}{109737}$$
$$= 680{\cdot}6$$
$$Z - 1 = 26$$
$\therefore$ $Z = 27$

Thus, the element is cobalt.

OBJECTIVE QUESTIONS

1. An X-ray machine is operated at 40 kV. The short wavelength limit of continuous X-rays is—
   (A) 1 Å (B) 3·1 Å
   (C) 0·31 Å (D) 2·5 Å
2. An X-ray machine uses X-rays of wavelengths 0·1 Å and greater. What voltage does it employ ?
   (A) 12·4 kV
   (B) 100 kV
   (C) $12{\cdot}4 \times 10^4$ volt
   (D) None of these
3. An X-ray tube with copper target is operated at 25 kV. The glancing angle for a NaCl crystal for the Cu K_α line is 15·8°. The wavelength of this line is, d for NaCl = 2·82 Å, sin 15·8 = 0·2723)
   (A) 1·53 Å (B) 1 Å
   (C) 2·53 Å (D) 1·35 Å
4. If the K_α radiation of M_0 (Z = 42) has a wavelength of 0·71 Å, the wavelength of the corresponding radiation of Cu (Z = 29) will be—
   (A) 2·51 Å (B) 3·51 Å
   (C) 4·52 Å (D) 1·52 Å
5. Which statement is correct ?
   (A) A coolidge tube acts as its own rectifier
   (B) In a coolidge tube intensity and hardness can not be changed independently
   (C) Hard X-rays can be produced by increasing filament current
   (D) When voltage across a coolidge tube is increased, more intense X-rays are produced
6. In order to study internal atomic structure of a crystal we should use—
   (A) Ultraviolet light
   (B) Infrared radiation
   (C) Yellow light
   (D) X-rays
7. In producing X-rays a beam of electrons accelerated through a potential difference V are made to strike a metal target. For what

value of V out of the following, X-rays have the lowest wavelength ?

(A) 10 kV (B) 20 kV
(C) 30 kV (D) 40 kV

8. The minimum wavelength of continuous X-ray radiation is—

(A) $\frac{Ve}{ch}$ (B) $\frac{Ve}{h}$
(C) $\frac{ec}{Vh}$ (D) $\frac{ch}{Ve}$

9. The shortest wavelength of X-rays emitted from an X-ray tube depends on—
(A) The current in the tube
(B) The voltage applied across the tube
(C) The nature of the gas in the tube
(D) The atomic number of the target material

10. If λ_1 and λ_2 are the wavelengths of characteristic X-rays and gamma rays respectively, then the relation between them is—

(A) $\lambda_1 = 1/\lambda_2$ (B) $\lambda_1 = \lambda_2$
(C) $\lambda_1 > \lambda_2$ (D) $\lambda_1 < \lambda_2$

11. The penetrating power of X-rays increases with the—
(A) Increase in intensity
(B) Increase in wavelength
(C) Decrease in frequency
(D) Increase in frequency

12. X-rays passing through a strong magnetic field—
(A) Get deflected in the direction of the field
(B) Get deflected in the direction opposite to that of the field
(C) Get deflected perpendicular to the direction of the field
(D) Do not get deflected at all

13. X-ray region lies between—
(A) Short radio waves and visible region
(B) Visible region and ultraviolet region
(C) Gamma rays and ultraviolet rays region
(D) Short radio waves and long radio waves region

14. The velocity of X-rays of wavelength 1 Å will be—

(A) $c/2$ (B) $c/3$
(C) c (D) $3c/4$

15. The lattice constant of a crystal is 2Å. The maximum wavelength of X-rays which can be analysed by this crystal will be—

(A) 1 Å (B) 2Å
(C) 3Å (D) 4Å

16. Hydrogen atom does not emit X-rays because—
(A) Its energy levels are very close to each other
(B) The energy levels are far apart from each other
(C) Its size is very small
(D) It contains only a single electron

17. The ratio of energies of X-rays of wavelengths 0·01 Å and 0·5 Å will be—

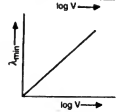
(A) 1 : 1 (B) 1 : 2
(C) 1 : 50 (D) 50 : 1

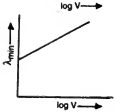
18. In a coolidge tube, the potential difference between cathode and anticathode is 120 kV. The maximum energy of emitted X-rays will be—

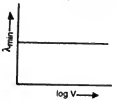
(A) $1{\cdot}2 \times 10^5$ eV (B) 10^{10} eV
(C) 10^{15} eV (D) 10^{20} eV

19. If the minimum wavelength of X-rays at V volt is λ_{min}, which of the following curves shows the graphical relation between log V and log λ_{min} ?

(A)


(B)


(C)


(D)


20. In coolidge tube, nearly what fraction of incident energy is utilised in producing X-rays ?

(A) 100 % (B) 50%
(C) 25% (D) 1%

ANSWERS

1. (C) 2. (C) 3. (A) 4. (D) 5. (A)
6. (D) 7. (D) 8. (D) 9. (B) 10. (C)
11. (D) 12. (D) 13. (C) 14. (C) 15. (D)
16. (A) 17. (D) 18. (A) 19. (A) 20. (D)

HINTS

1. $\lambda_{min} = \frac{hc}{eV}$

$= \frac{6{\cdot}63 \times 10^{-34} \times 3 \times 10^8}{1{\cdot}6 \times 10^{-19} \times 40 \times 10^3}$

$= 0{\cdot}31 \times 10^{-10}$ m

$= 0{\cdot}31$ Å

Short Method

$\lambda_{min} = \frac{12375}{V}$ Å

$= \frac{12375}{40 \times 10^3}$

$= 0{\cdot}31$ Å

2. $\lambda_{min} = \frac{12375}{V}$ Å

$\therefore \quad V = \frac{12375}{\lambda_{min}}$

$= \frac{12375}{0{\cdot}1}$

$= 12{\cdot}4 \times 10^4$ volt.

3. From Bragg's law

$2d \sin\theta = n\lambda$

or, $2 \times 2{\cdot}82 \times 0{\cdot}2723 = 1 \times \lambda$

or, $\lambda = 1{\cdot}53$ Å

4. From Moseley's law (b for K_α line = 1)

$(Z-1)^2 \propto \upsilon$

or, $(Z-1)^2 = A \cdot \frac{c}{\lambda_{K_\alpha}}$

where A is some constant,
Thus

$\frac{(Z_{Mo}-1)^2}{(Z_{Cu}-1)^2} = \frac{\lambda_{Cu}}{\lambda_{Mo}}$

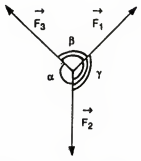
(Continued on Page 1740)

LAMI'S THEOREM AND ITS APPLICATIONS

It is widely seen that students of Physics tend to apply the methods of balancing components of vectors in almost all problems related to equilibrium of bodies; but in many cases, if they apply Lami's theorem instead, the solution would be faster to arrive at.

This theorem is very simple in its concept, derivation as well as its applications. Firstly one should be careful that the body (or the particle) on which this theorem is to be applied, is in equilibrium (*i.e.*, the net force on it is zero). Secondly there must be exactly three forces acting on the body.

Statement : The theorem states that if three forces acting on a body keep it in equilibrium (See figure), then we must have :

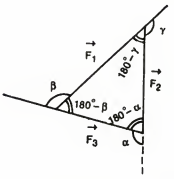


$$F_1/(\sin(\alpha)) = F_2/(\sin(\beta)) = F_3/(\sin(\gamma)) \quad \ldots(1)$$

Proof : The proof is very easy to follow. One must first realise that the resultant of three vectors is zero, if and only if, the three vectors, maintaining their magnitudes and directions, are capable of forming the three sides of a closed triangle.

Refer figure 2. If the three vectors of figure 1 are able to form a triangle, then we can redraw the figure 1 as figure 2 and mark the angles as shown. Also a triangle obeys the Sine law, hence we must have :

$$F_1/(\sin(180° - \alpha)) = F_2/(\sin(180° - \beta)) = F_3/(\sin(180° - \gamma))$$



After noting that $\sin(180° - A) = \sin(A)$, we get the theorem as in equation (1).

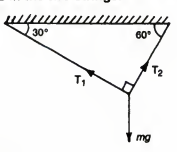
Also note that in applying Lami's theorem, many times it is necessary to make use of the following facts from trigonometry :

$$\sin(180° - A) = \sin(A)$$
$$\text{and} \quad \sin(90° + A) = \cos(A)$$

SOME IMPORTANT SOLVED EXAMPLES

The following are certain solved problems where Lami's theorem can easily be applied :

Example 1. Two strings are connected to the horizontal ceiling, one making an angle of 30° and the another making an angle of 60° and a mass of 10 kg is connected to them which is hanging vertically. Find the tensions in the two strings.



Solution :

Consider the point of contact as a particle where this theorem is to be applied. Since it is in equilibrium, we must have :

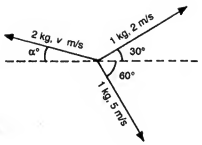
$$mg/\sin(90°) = T_1/\sin(150°) = T_2/\sin(120°)$$

Hence, $T_1 = mg \ldots \sin(150°) = 100 \times 0{\cdot}5 = 50{\cdot}0$ newtons

and $T_2 = mg \,.\, \sin(120°) = 86{\cdot}6$ newtons

[**Note**—One may try solving this problem by the method of balancing components and the advantage in this method will be immediately apparent.]

Example 2. A body of mass 4 kg, at rest, explodes into three pieces of masses 1 kg, 1 kg and 2 kg. The first 1 kg mass flies at an angle 30° to the *x*-direction with a speed of 2 m/s; the second 1 kg mass flies at an angle 60° below *x*-axis with a speed 5 m/s. Find the magnitude and direction of the speed with which the third mass of 2 kg flies.



Solution :

[See figure] Let the speed of the third mass be v in a direction $a°$ with the negative x-axis. Applying Lami's theorem, we get :

$$2v / \sin(90°) = 2 / \sin(120° + \alpha)$$
$$= 5 / \sin(150° - \alpha)$$

Hence, $2 . \sin(150° - \alpha) = 5 . \sin(120° + \alpha)$

or, $\cos(\alpha) + \sqrt{3} \sin(\alpha) = 2{\cdot}5 \times [\sqrt{3} \cos(\alpha) - \sin(\alpha)]$

or, $(2{\cdot}5\sqrt{3} - 1) . \cos(\alpha) = (\sqrt{3} + 2{\cdot}5) . \sin(\alpha)$

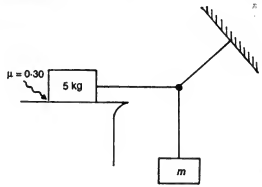
Hence $\alpha = 38{\cdot}2°$

Therefore, the third mass [2 kg] flies off at an angle of 51·8° with the positive direction of y-axis with speed

$$= \frac{2{\cdot}5}{\sin(111{\cdot}2)} = 2{\cdot}68 \text{ m/s}$$

Example 3. A block of mass 5 kg is kept on a rough table and a string is tied to it. Other strings are tied as shown with a mass hanging vertically. [See figure]. If the co-efficient of friction is 0·30, find the maximum value of m so that the block does not slide.

Solution :



Applying Lami's theorem at the knot

$$mg / \sin(135°) = F_{fr} / \sin(135°)$$

Hence, $mg = \mu . Mg$

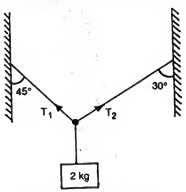
or, $m = 0{\cdot}3 \times 5$

$= 1{\cdot}5$ kg

PROBLEMS FOR PRACTICE

The following are certain problems where Lami's theorem is typically applicable (based on the types solved above, for your practice); solve them and check with the answers given alongwith :

(1) Three strings are connected as shown in the figure to two vertical walls and a mass of 2 kg. The strings



connected to the walls make angles 45° and 30° with the walls respectively. Find the tensions in the two strings.

$T_1 = 10{\cdot}35$ N

$T_2 = 14{\cdot}64$ N

(2) A large mass of 6 kg breaks into three fragments of masses 1 kg, 2 kg and 3 kg. One mass (1 kg) flies along the x-axis with a speed 2 m/s, another (2 kg) flies at 60° to the x-axis with a speed of 3 m/s. Find the speed and direction in which the third mass goes.

$\alpha = 46{\cdot}10°$ with negative x-axis at speed 2·4 m/s.

(3) Rain is falling at an angle of 30° with the vertical at a speed of 10 m/s. A man is moving in the direction of rainfall and to him the rain appears to fall at an angle of 30° with the horizontal. Find the speed of the person and the relative speed of rainfall.

Speed of person = 10 m/s

Relative speed = 17·32 m/s

(4) The resultant of three vectors is zero. One vector is of length 12 along positive direction of x-axis, second vector is of length 8 at a direction 120° with the positive x-axis. Find the magnitude and direction of the third vector.

Magnitude = 8,

at $60° + 180° = 240°$ with + ve x-axis.

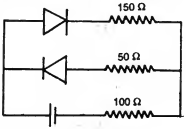
●●●

Food and Drug Administration (FDA) approved New Drugs

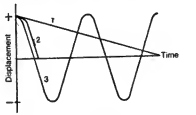
Taxol	Refractory breast cancer
Navelbine	Advanced non-small-cell lung cancer
Zinecard	Chemotherapy protectant
Aredia	Bone metastases in multiple myeloma
Casodex	Advanced prostate cancer
Doxil	Kaposi's sarcoma
Vesanoid	Acute promyelocytic leukemia
Ethyol	Chemotherapy protectant
Zoladex	Advanced breast cancer
Photofrin	Esophageal cancer
Arimidex	Advanced breast cancer

PHYSICS

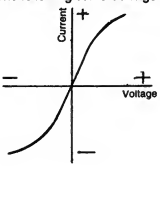
1. Which of the following measurements is most accurate?
   (A) 50·00 m (B) 5·00 m
   (C) 5·00 cm (D) 5·00 mm
2. Which of the following measurements is most precise?
   (A) 50·00 m (B) 5·00 m
   (C) 5·00 cm (D) 5·00 mm
3. A motor moves on a circular path of radius 500 m with a speed of 30 m/s. It speeds up at a rate of 2 m/s^2. Its acceleration will be—
   (A) 2·7 m/s^2 (B) 3·8 m/s^2
   (C) 0.2 m/s^2 (D) 2 m/s^2
4. A particle of mass m is projected upwards from a point P on the surface of the earth with a speed v_0 at an angle θ to the horizontal. The magnitude and direction of the angular momentum vector about the point P are given by—
   (A) $\left(\frac{m v_0 \sin 2\theta}{2g}\right)(\hat{i})$
   (B) $\left(\frac{m v_0^2 \sin\theta \cdot \cos 2\theta}{g}\right)(\hat{j})$
   (C) $\left(\frac{m v_0^2 \sin^2\theta}{2g}\right)(\hat{k})$
   (D) $\left(\frac{m v_0^3 \sin^2\theta \cos\theta}{2g}\right)(-\hat{k})$
5. Two freely hanging weights, each having a mass of 60 g, are connected by a light thread which passes over a fixed pulley. The mass of the pulley and frictional losses are negligible. If a 10 g weight is now added to one of the weights, its downward acceleration, in cm/s^2, will be approximately—
   (A) 32 (B) 80
   (C) 160 (D) 980
6. Two blocks of mass m_1 = 10 kg and m_2 = 5 kg, connected to each other by a massless inextensible string of length 0·3 m are placed along a diameter of a turn table. The coefficient of friction between the turn table and m_1 is 0·5 while there is no friction between m_2 and the table. The table is rotating with an angular velocity of 10 rad/s about a vertical axis passing through its centre O. The masses are placed along the diameter of the table on either side of the centre O such that the mass m_1 is at the distance of 0·124 m from O. The masses are observed to be at rest with respect to an observer on the turn table. The frictional force on m_1 is—
   (A) 36 N (B) 20 N
   (C) 10 N (D) 15 N
7. A band playing music at a frequency f is moving towards a wall at a speed v_b. A motorist is following the band with a speed v_m. If v is the speed of sound, the beat frequency heard by the motorist is—
   (A) $f\left[\frac{v_b(v+2v_m)}{v^2-v_b^2}\right]$
   (B) $f\left[\frac{2v_b(v+v_m)}{v^2-v_b^2}\right]$
   (C) $f\left[\frac{v_b^2(v+v_m)}{v-v_b}\right]$
   (D) $f\left[\frac{2v_b(v+v_m)}{v^2+v_b^2}\right]$
8. The circuit shown in the figure contains two diodes each with a forward resistance of 50 ohms and with infinite backward resistance. If the battery voltage is 6 V, the current through the 100 ohm resistance (in amperes) is–



   (A) Zero (B) 0·02
   (C) 0·03 (D) 0·036
9. A satellite is projected with a velocity $\sqrt{1{\cdot}5}$ times its orbital velocity just above earth atmosphere. The initial velocity of the satellite is parallel to the surface. The maximum distance of the satellite from earth will be—
   (A) 2 R (B) 8 R
   (C) 4 R (D) 3 R
10. Which of the curves given in the following graph represents the critical damping ?



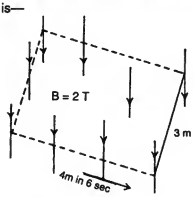
    (A) 1 (B) 2
    (C) 3 (D) 1 and 3 both
11. Imagine a geostationary satellite of earth which is used as an intercontinental telecast station. At what height will it have to be established ?
    (A) 10^3 m
    (B) $6{\cdot}4 \times 10^3$ m
    (C) $35{\cdot}945 \times 10^6$ m
    (D) At infinity
12. The constant potential gradient means—
    (A) The electric field is zero
    (B) The potential is uniform
    (C) The electric field is uniform
    (D) The electric field is non-uniform
13. The relative permittivity of polythene is—
    (A) Zero (B) 1
    (C) 2·3 (D) Infinity
14. The number density of free electrons for copper is—
    (A) 6×10^{23} m^{-3}
    (B) 10^6 m^3
    (C) 8×10^{28} m^{-3}
    (D) Infinite
15. The following curve belongs to—



(A) Wire (metal) at constant temperature
(B) Bulb filament
(C) Diode (semi conductor)
(D) None of the above

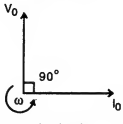
16. Magnetic flux density inside a solenoid with a core is given by–
(A) $B = \frac{\mu_0 I}{2\pi a}$
(B) $B = \frac{\mu_0 NI}{2r}$
(C) $B = \mu_0 n I$
(D) $B = \mu_r \mu_0 nI$

17. The conductor given below is cutting magnetic flux. It moves a distance of 4 m in 6 seconds, at a steady speed. From the data supplied, the potential difference across the ends of the conductor is—



(A) 4 volt (B) Zero
(C) 6 volt (D) 0·01 volt

18. The following phasor diagram corresponds to—



(A) An ohmic circuit
(B) An inductive circuit
(C) A capacitor circuit
(D) An L–C–R circuit

19. Which of the following properties is not associated with an amorphous solid ?
(A) They are isotropic
(B) They do not have a sharp melting point
(C) They are not bounded by flat surfaces
(D) They have orderly arrangement of atoms and molecules

20. A source emits 31·4 W of radiant flux distributed uniformly in all directions. The luminous efficiency is 60 lumen/watt. What is the luminous intensity of the source ?
(A) 150 Cd (B) 100 Cd
(C) 50 Cd (D) 200 Cd

21. The primary colours are—
(A) Yellow, red, magenta
(B) Magenta, blue, cyan
(C) Cyan, green, yellow
(D) Red, blue, green

22. The ratio of the diameters of Fresnel's fourth and ninth half period zones is—
(A) 2 : 3 (B) 3 : 2
(C) 2 : 4 (D) 4 : 2

23. Light of wavelength $6{\cdot}5 \times 10^{-7}$ m is made incident on two slits 1 mm apart. The distance between third dark fringe and fifth bright fringe on a screen distant 1 m from the slits will be—
(A) 0·35 mm (B) 0·65 mm
(C) 1·63 mm (D) 3.25 mm

24. A capacitor is charged by a battery and then discharged through a resistor. Increasing the resistor renders—
(A) A slower discharge
(B) A faster discharge
(C) Damage of capacitor
(D) No discharge at all

25. The probability of a radioactive atom to survive 5 times longer than its half value period is—
(A) 2/5 (B) 2×5
(C) 2^{-5} (D) 2^5

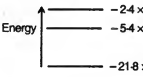
26. Sodium has a threshold frequency of $4{\cdot}4 \times 10^{14}$ Hz. What is the stopping potential when the sodium is irradiated with light of frequency $6{\cdot}0 \times 10^{14}$ Hz ?
(A) 0·66 volt (B) 2·0 volt
(C) 6·1 volt (D) 5 volt

27. A monitoring device aboard an aircraft registers a dose equivalent rate of 16 $\mu S_v\ h^{-1}$. What is the dose equivalent during a 7-hour flight ?
(A) 160 μS_v (B) 112 μS_v
(C) 100 μS_v (D) 200 μS_v

28. Thermoplastics—
(A) Soften when heated and harden on cooling
(B) Soften whether heated or cooled
(C) Harden when heated and soften on cooling
(D) Harden whether heated or cooled

29. The channels for communication may be—
(A) Radiowaves and microwave beam
(B) Metal cable
(C) Optical fibres
(D) All the above

30. The diagram represents three possible energy levels of an atom of hydrogen. When the energy of an electron changes from a higher to a lower energy level, a quantum of electromagnetic radiation is emitted. The lowest wavelength emitted is—



(A) $1{\cdot}02 \times 10^{-7}$ m
(B) $10{\cdot}2 \times 10^{-7}$ m
(C) $13{\cdot}6 \times 10^{-7}$ m
(D) $9{\cdot}1 \times 10^{-7}$ m

31. Consider the fission reaction of uranium-235 resulting in the formation of the stable elements molybdenum and xenon :

$$_{92}U^{235} + {}_0n^1 \longrightarrow {}_{42}Mo^{98} + {}_{54}Xe^{136} + 2\,{}_0n^1 + 4\,{}_{-1}\beta^0$$

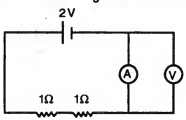
$[{}_{92}U^{235} = 234{\cdot}993u,\ {}_0n^1 = 1{\cdot}009u,\ {}_{42}Mo^{98} = 97{\cdot}883u,\ {}_{54}Xe^{136} = 135{\cdot}878u,\ {}_{-1}\beta^0 = 0{\cdot}0005u]$

The energy equivalence is—
(A) 5×10^{-10} J
(B) 1×10^{-9} J
(C) 6×10^{-12} J
(D) $3{\cdot}32 \times 10^{-11}$ J

32. Which of the following hands in a solid never remains empty ?
(A) Valence band
(B) Conduction band

(C) Forbidden band
(D) None of the above

33. In the circuit shown, A and V are ideal ammeter and voltmeter. The voltmeter reading will be—



(A) 2 V (B) 1 V
(C) 0·5 V (D) Zero

34. A thermodynamical system absorbs 100 calories of heat and performs 30 joules of work. If J = 4·2 joules/calorie, the change in its internal energy will be—
(A) 14 joules
(B) 140 joules
(C) 390 joules
(D) 450 joules

35. Molar specific heat of oxygen at constant pressure. $C_p = 7{\cdot}2$ Cal/mol°C and R = 2 calorie/mol°C. At constant volume 5 mol of oxygen is heated from 10°C to 20°C, the quantity of heat required is approximately—
(A) 25 Cal (B) 50 Cal
(C) 250 Cal (D) 500 Cal

36. For Cu–Fe couple, the thermo e.m.f. (temperature of cold junction = 0°C) is given by $E = (14\theta - 0{\cdot}02\theta^2)\ \mu V$. The neutral temperature will be—
(A) 350°C (B) 350 K
(C) 560°C (D) 560 K

37. The exposure time is—
(A) Inversely proportional to the square of diameter of the aperture
(B) Directly proportional to *f*-number
(C) Inversely proportional to *f*-number
(D) Inversely proportional to square of *f*-number

38. Two soap bubbles of radii 4 cm and 5 cm coalesce to form a common surface. The radius of curvature of this common surface will be—
(A) 20 cm (B) 1 cm
(C) 1·25 cm (D) $\sqrt{41}$ cm

39. Reynold's number is—
(A) Inertial force/viscous force
(B) Viscous force/inertial force
(C) Viscous force × inertial force
(D) Inertial mass / gravitational mass

40. The unit of coefficient of viscosity in SI system is—
(A) m/kg–s (B) m–s/kg^2
(C) kg/m–s^2 (D) kg/m–s

41. Characteristic X-rays are produced when the bombarding electron—
(A) Knocks out an electron from the inner shell of the target atom
(B) Is brought to rest by the nucleus of the target
(C) Exchanges position with an electron of the inner shell of the target atom
(D) Passes out through the target atom

42. A plate current of 10mA is obtained when 60 volts are applied across a diode tube. Assuming the Langmuir–Child equation $i_p \propto v_p^{3/2}$ to hold, find the dynamic resistance r_p in this operating condition.
(A) 1 kΩ (B) 2 kΩ
(C) 3 kΩ (D) 4 kΩ

43. The focal length of a thin lens in vacuum is f. If the material of the lens has a refractive index of 3/2, its focal length, when immersed in water of refractive index $\frac{4}{3}$ will be—
(A) f (B) $\frac{4f}{3}$
(C) $2f$ (D) $4f$

44. An ideal heat engine operates in a Carnot cycle between 227°C and 127°C. It absorbs 10^4 J of heat at the higher temperature. The amount of heat converted to work is—
(A) 2000 J (B) 8000 J
(C) 4400 J (D) 5600 J

45. The thermal neutrons in a nuclear reactor may be regarded as a gas, at a temperature T, which obeys the postulates of the kinetic theory. The de Broglie wavelength of such thermal neutrons may be expressed as—
(A) $\frac{h}{3\sqrt{mkT}}$ (B) $\frac{3h}{\sqrt{mkT}}$
(C) $\frac{k}{\sqrt{3hT}}$ (D) $\frac{h}{\sqrt{3\ mkT}}$

46. The dimensions of a rectangular parallelopiped are 1 cm × 1 cm × 100 cm. If its specific resistance is $3 \times 10^{-7}\Omega \times$ m, the resistance between its rectangular faces will be—
(A) $3 \times 10^{-9}\Omega$ (B) $3 \times 10^{-7}\Omega$
(C) $3 \times 10^{-5}\Omega$ (D) $3 \times 10^{-3}\Omega$

47. The cause of diamagnetism is—
(A) Orbital motion of electrons
(B) Spin motion of electrons
(C) Paired electrons
(D) None of the above

48. The relation between μ and H for a specimen of iron is as given below :
$$\mu = \left[\frac{0{\cdot}4}{H} + 12 \times 10^{-4}\right] \text{ henry/meter}$$
The value of H which produces flux density of 1 Tesla will be—
(A) 250 A/m (B) 500 A/m
(C) 750 A/m (D) 10^3 A/m

49. The electromagnetic waves out of the following are—
(A) X-rays
(B) Cathode rays
(C) Positive rays
(D) β-rays

50. The ratio of the velocity of a body and the velocity of sound is known as—
(A) Mach number
(B) Boltzmann's constant
(C) Wave number
(D) Laplace number

ANSWERS

1. (A) 2. (D) 3. (A) 4. (D) 5. (B)
6. (A) 7. (B) 8. (B) 9. (D) 10. (B)
11. (C) 12. (C) 13. (C) 14. (C) 15. (B)
16. (D) 17. (A) 18. (B) 19. (D) 20. (A)
21. (D) 22. (A) 23. (C) 24. (A) 25. (C)
26. (A) 27. (B) 28. (A) 29. (D) 30. (A)
31. (D) 32. (A) 33. (D) 34. (C) 35. (C)
36. (A) 37. (A) 38. (A) 39. (A) 40. (D)
41. (A) 42. (D) 43. (D) 44. (A) 45. (D)
46. (B) 47. (A) 48. (B) 49. (A) 50. (A)

HINTS

1.

L	ΔL	$\frac{\Delta L}{L}$	$\frac{\Delta L}{L} \times 100$
50·00 m	0·01 m	2×10^{-4}	0·02%
5·00 m	0·01 m	2×10^{-3}	0·2%
5·00 cm	0·01 cm	2×10^{-3}	0·2%
5·00 mm	0·01 mm	2×10^{-3}	0·2%

The first measurement is most accurate since it involves least percentage error.

2. The last measurement is most precise, for it has been obtained from an instrument of minimum leastcount ·01 mm.

3. Resultant acceleration $= \sqrt{a_t^2 + a_r^2}$

Centripetal acceleration $a_r = \frac{v^2}{r} = \frac{30 \times 30}{500}$

$= 1{\cdot}8\ m/s^2$

and tangential acceleration $= 2\ m/s^2$

$\therefore$ Resultant acceleration $= \sqrt{(1{\cdot}8)^2 + (2)^2}$

$= \sqrt{3{\cdot}24 + 4}$

$= 2{\cdot}7\ m/s^2$

4. If $\vec{r}$ be the position vector at maximum height, then

$r_x \hat{i} = \frac{1}{2} \times$ Range

$= \frac{v_0^2 \sin 2\theta}{2g}(\hat{i})$

and $r_y(\hat{j}) =$ max. height

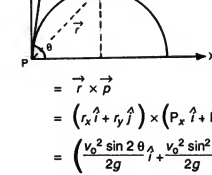
$= \frac{v_0^2 \sin^2 \theta}{2g}$

moment at the highest point $\vec{p}$

$= mv_0 \cos\theta\,(\hat{i})$

angular momentum

= moment of momentum



$= \vec{r} \times \vec{p}$

$= \left(r_x \hat{i} + r_y \hat{j}\right) \times \left(P_x \hat{i} + P_y \hat{j}\right)$

$= \left(\frac{v_0^2 \sin 2\theta}{2g}\hat{i} + \frac{v_0^2 \sin^2 \theta}{2g}\hat{j}\right) \left(mv_0 \cos\theta\,\hat{i}\right)$

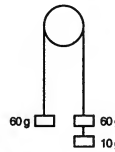
$= \frac{mv_0^3 \sin^2 \theta \cos\theta}{2g}(-\hat{k})$

5. The accelerating force F

$= 10g \qquad (g = 980\ cm/s^2)$

Accelerated weight W

$= (60 + 60 + 10) = 130\ g$



Let a be the acceleration

$\therefore \quad F = W{\cdot}a$

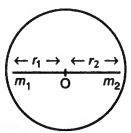
$10 \times 980 = 130 \times a$

$a = \frac{10 \times 980}{130} \simeq 80\ cm/s^2$

6. Given $r_1 = 0{\cdot}124$ m

$\therefore \quad r_2 = 0{\cdot}3 - 0{\cdot}124$ m

$= 0{\cdot}176$ m



Centrifugal force on $m_1 = m_1 r_1 \omega^2$

Frictional force on $m_1 = F$

$\therefore$ Resultant force on $m_1 = (m_1 r_1 \omega^2 - F)$

Centripetal force on $m_2 = m_2 r_2 \omega^2$

For equilibrium

$m_1 r_1 \omega^2 - F = m_2 r_2 \omega^2$

or, $F = (m_1 r_1 - m_2 r_2)\omega^2$

$= (10 \times 0{\cdot}124 - 5 \times 0{\cdot}176) \times 10^2$

$= (1{\cdot}24 - 0{\cdot}88) \times 100$

$= 36$ N

7. The frequency heard by motorist

$f_{m'} = \frac{v + v_m}{v + v_b} f$

Frequency heard at wall

$f_{w'} = \frac{v}{v - v_b} f$

Frequency reflected by wall and heard by motorist

$f_{m''} = \frac{v + v_m}{v} f_{w'}$

$$= \frac{v+v_m}{v} \times \frac{v}{v-v_b} f$$

$$= \frac{v+v_m}{v-v_b} f$$

$\therefore$ Frequency of beats heard by motorist

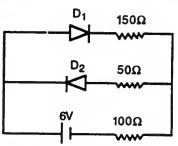
$$\Delta f = f_m'' - f_m'$$

$$= \frac{v+v_m}{v-v_b} f - \frac{v+v_m}{v+v_b} f$$

$$= (v+v_m) f \times \left[\frac{(v+v_b)-(v-v_b)}{v^2-v_b^2}\right]$$

$$= \frac{2v_b(v+v_m)}{v^2-v_b^2} f$$

8. In the circuit only the diode will conduct as it is forward biased.



So current $I = \frac{6V}{(50+150+100)\,\Omega}$

$$= \frac{6}{300} A$$

$$= 0{\cdot}02 A$$

9. $$\frac{1}{2}mv^2 = \frac{GMm}{R} - \frac{GMm}{R+h}$$

or, $$\frac{1}{2}v^2 = \frac{gR^2}{R} - \frac{gR^2}{R+h}$$

or, $$\frac{1}{2}v^2 = gR - \frac{gR^2}{R+h}$$

or, $$\frac{1}{2} \times \left(\sqrt{1{\cdot}5\,Rg}\right)^2 = gR - \frac{gR^2}{R+h}$$

or, $$0{\cdot}75\,Rg = gR - \frac{gR^2}{R+h}$$

or, $$0{\cdot}75 = 1 - \frac{R}{R+h}$$

or, $$h = 3R$$

10. In critical damping, the time taken by the oscillating system for the displacement to settle to zero is a minimum.

11. $$T = 2\pi \frac{(R+h)^{3/2}}{R\sqrt{g}}$$

$$\therefore h = \left[\frac{TR\sqrt{g}}{2\pi}\right]^{2/3} - R$$

$$= \left[\frac{24 \times 3600 \times 6{\cdot}4 \times 10^6 \times \sqrt{9{\cdot}8}}{2 \times 3{\cdot}14}\right]^{2/3} - 6{\cdot}4 \times 10^6$$

$$= 35{\cdot}945 \times 10^6 \text{ m}$$

14. By number density we mean the number of free electrons per unit volume (per m^3)

16. $B = \mu_r \mu_0 nI$, here μ_0 is the permeability of free space, μ_r the relative permeability of the material, n the no. of turns per unit length and I is the current.

17. Area of flux cut $A = 3 \times 4 = 12\ m^2$

$\therefore$ Flux cut $= B \cdot A = 2 \times 12$

$= 24$ Wb

$\therefore$ P.D. $= E = \frac{\Delta\phi}{\Delta t} = \frac{24}{6} = 4$ V

18. In an inductive circuit, the voltage leads the current by an angle of 90°.

20. Luminous efficiency

$$= \frac{\text{Total luminous flux}}{\text{Total radiant flux}}$$

$\therefore$ Total luminous flux

= Luminous efficiency × total radiant flux

$= 60 \times 31{\cdot}4$

Hence $I = \frac{F}{4\pi} = \frac{60 \times 31{\cdot}4}{4\pi}$

$$= \frac{60 \times 31{\cdot}4}{4 \times 3{\cdot}14}$$

$= 150$ Cd.

22. $\because$ $r_n = \sqrt{nb\lambda}$

$\therefore$ $D_n = 2r_n = 2\sqrt{nb\lambda}$

$D_4 = 2\sqrt{4b\lambda}$

$D_9 = 2\sqrt{9b\lambda}$

$\therefore$ $\frac{D_4}{D_9} = \frac{2\sqrt{4b\lambda}}{2\sqrt{9b\lambda}} = \frac{2}{3}$

23. Distance of 3rd dark fringe from centre

$$x_3 = (2m-1)\frac{\lambda D}{2d}$$

$$= (2 \times 3 - 1)\frac{\lambda D}{2d} = \frac{5\lambda D}{2d}$$

Distance of 5th bright fringe from centre

$$x_5 = \frac{n\lambda D}{d} = \frac{5\lambda D}{d}$$

$\therefore$ $x_5 - x_3 = \frac{5\lambda D}{d} - \frac{5\lambda D}{2d} = \frac{5\lambda D}{2d}$

$$= \frac{5 \times 6{\cdot}5 \times 10^{-7} \times 1}{2 \times 10^{-3}}$$

$$= 16{\cdot}25 \times 10^{-4} \text{ m} = 1{\cdot}63 \text{ mm}$$

24. Time constant = RC. On increasing R, the time constant increases; as a consequence the discharge is slowered down.

25. Total time of decay = half life × no. of half lives.

$t = t_{1/2} \times n$

Given $t = 5t_{1/2}$

$5t_{1/2} = t_{1/2} \times n$

$n = 5$

Survival probability of radioactive atom

$$= \frac{N}{N_o} = \left(\frac{1}{2}\right)^n$$

$$= \left(\frac{1}{2}\right)^5 = 2^{-5}$$

26. $h\upsilon = h\upsilon_o + eV_o$ ($V_o \rightarrow$ Stopping potential)

$$\therefore \quad V_o = \frac{h(\upsilon - \upsilon_0)}{e}$$

$$= \frac{6{\cdot}6 \times 10^{-34}(6{\cdot}0 - 4{\cdot}4)\,10^{14}}{1{\cdot}6 \times 10^{-19}}$$

$$= \frac{6{\cdot}6 \times 1{\cdot}6 \times 10^{-1}}{1{\cdot}6}$$

$$= 0{\cdot}66 \text{ volt}$$

27. Dose equivalent = Dose equivalent rate × time

$$= 16 \times 10^{-6} \times 7$$

$$= 112 \times 10^{-6}$$

$$= 112\ \mu S_v.$$

30. The widest gap corresponds to lowest wavelength.

Thus $\lambda_{min} = \frac{hc}{\Delta E}$

$$= \frac{6{\cdot}63 \times 10^{-34} \times 3 \times 10^8}{-2{\cdot}4 \times 10^{-19} - (-21{\cdot}8 \times 10^{-19})}$$

$$= \frac{6{\cdot}63 \times 3 \times 10^{-26}}{(21{\cdot}8 - 2{\cdot}4) \times 10^{-19}}$$

$$= \frac{6{\cdot}63 \times 3 \times 10^{-7}}{19{\cdot}4}$$

$$= 1{\cdot}02 \times 10^{-7} \text{ m}$$

31.

Before		After	
$_{92}U^{235}$	234·993 u	$_{42}Mo^{98}$	97.883 u
$_0n^1$	1·009 u	$_{54}Xe^{136}$	135·878 u
		$2\ _0n^1$	2·018 u
Total mass	236·002 u	$4\ _{-1}\beta^0$	0·002 u
		Total mass	235·781 u

$\therefore$ Mass defect Δm = 236·002 − 235·781 u

$$= 0{\cdot}221\ u$$

$$= 0{\cdot}221 \times 1{\cdot}660 \times 10^{-27} \text{ kg}$$

$$= 0{\cdot}369 \times 10^{-27} \text{ kg}$$

Energy equivalence $E = mc^2$

$$= 0{\cdot}369 \times 10^{-27} \times (3 \times 10^8)^2$$

$$= 0{\cdot}369 \times 10^{-27} \times 9 \times 10^{16}$$

$$= 3{\cdot}32 \times 10^{-11} \text{ J}$$

33. The voltmeter is connected across an ammeter with zero resistance. So the reading will be zero.

34. $dQ = du + dw$

$100 \times 4{\cdot}2 = du + 30$

$du = 390$ joules

35. $C_v = C_p - R$

$= 7{\cdot}2 - 2 = 5$ Cal/mol °C

$\therefore \quad H = nC_v\,dT$

$= 5 \times 5 \times (20 - 10)$

$= 250$ Cal.

36. Given $E = (14\theta - 0{\cdot}02\theta^2)\ \mu V$

$$\frac{dE}{d\theta} = 14 - 0{\cdot}04\,\theta$$

At neutral temperature

$$\frac{dE}{d\theta} = 0$$

$$\therefore \quad 0 = 14 - 0{\cdot}04\,\theta$$

$\theta = 350°C$

37. $\frac{t_1}{t_2} = \frac{d_2^2}{d_1^2}$ [$t \rightarrow$ exposure time; $d \rightarrow$ diameter of aperture]

38. $R = \frac{R_1 R_2}{R_2 - R_1}$

$$= \frac{5 \times 4}{5 - 4} = 20 \text{ cm}$$

42. $i_p = k v_p^{3/2}$

$$\frac{di_p}{dv_p} = k \cdot \frac{3}{2} \cdot v_p^{1/2}$$

$$\frac{dv_p}{di_p} = \frac{2}{3k\,v_p^{1/2}}$$

$$\frac{dv_p}{di_p} \times i_p = \frac{2}{3k\,v_p^{1/2}} \cdot k \cdot v_p^{3/2} = \frac{2}{3} v_p$$

$$\frac{dv_p}{di_p} = \frac{2}{3}\frac{v_p}{i_p}$$

$$= \frac{2}{3} \times \frac{60}{10 \times 10^{-3}}$$

$$= 4 \times 10^3\ \Omega = 4\,k\Omega$$

43. $\frac{1}{f} = (_a\mu_g - 1)\,G$

$$= (1{\cdot}5 - 1)\,G = \frac{G}{2}$$

$$\Rightarrow \quad G = \frac{2}{f}$$

$$\frac{1}{f_w} = (_w\mu_g - 1)G$$

$$= \left(\frac{_a\mu_g - {}_a\mu_w}{{}_a\mu_w}\right)G$$

$$= \left(\frac{3/2 - 4/3}{4/3}\right)G$$

$$= \frac{1}{8} \times \frac{2}{f} = \frac{1}{4f}$$

$f_w = 4f$

44. $T_1 = 227°C = 227 + 273$

$= 500$ K

$T_2 = 127°\,C = 127 + 273$

$= 400$ K;

$Q = 10^4$ J

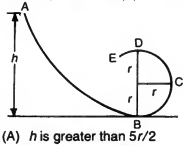
(Continued on Page 1833)

PHYSICS

1. A motor boat covers the distance between two spots on the river in t_1 = 8 hr and t_2 = 12 hr down stream and upstream respectively. The time required for the boat to cover this distance in still water is—
   (A) 4·3 hr (B) 9·6 hr
   (C) 0·21 hr (D) 0·42 hr

2. Four persons K, L, M, N are initially at the four corners of a square of side d. Each person now moves with a uniform speed v in such a way that K always moves directly towards L, L directly towards M, M directly towards N and N directly towards K. The four persons will meet at a time—
   (A) $2d/v$ (B) $\sqrt{2}d/v$
   (C) d/v (D) $v\sqrt{2}\,d$

3. In figure, ABCD is a channel in a vertical plane, part BCDE being circular with radius r. A ball is released from A and slides without friction and without rolling. It will complete the loop path if—



   (A) h is greater than $5r/2$
   (B) h is less than $5r/2$
   (C) It will not complete the loop
   (D) h is equal to $7r/5$

4. An insect is crawling up a fixed hemispherical bowl of radius R. It can only crawl upto a height h of the radius of the bowl if the coefficient of friction is 1/3. The value of h should be equal to—
   (A) R (B) 0·051 R
   (C) 0·949 R (D) 1·523 R

5. A uniform chain is held on a frictionless table with one fifth of its length hanging over the edge. If the chain has a length l and mass m, then the work required to pull the hanging part back on the table is—
   (A) $\frac{mg}{50\,l}$ (B) $\frac{50\,ml}{g}$
   (C) $\frac{50\,mg}{l}$ (D) $\frac{mgl}{50}$

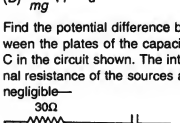
6. A wire of density 9 g/cm^3 is stretched between two clamps 100 cm apart, while subjected to an extension of 0·05 cm. What is the lowest frequency of transverse vibrations in the wire assuming Young's modulus of the material to be 9×10^{11} dyne/cm^2 ?
   (A) 35·3 Hz
   (B) 15·2 Hz
   (C) 46·4 Hz
   (D) None of the above

7. A man is travelling along a straight line joining two sources each of 1000 vib/sec. How fast should he move, so that he may hear 15 beats per second ? (Velocity of sound = 330 m/s)—
   (A) 1·46 m/s (B) 2·48 m/s
   (C) 3·93 m/s (D) 0·53 m/s

8. A jar contains a gas and a few drops of water at TK. The pressure in the jar is 830 mm of mercury. The temperature of the jar is reduced by 1%. The saturated vapour pressure of water at the two temperatures is 30 and 25 mm of mercury. The new pressure in the jar will be—
   (A) 125 mm of Hg
   (B) 436 mm of Hg
   (C) 817 mm of Hg
   (D) 1125 mm of Hg

9. A pith ball covered with tinfoil having a mass of m kg hangs by a fine silk thread l meter long in an electric field E. When the ball is given an electric charge of q coulomb, it stands out d metre from the vertical line. The electric field is given by—
   (A) $\frac{mgd}{q\sqrt{l^2 - d^2}}$
   (B) $\frac{mgd}{q}\sqrt{l^2 - d^2}$
   (C) $\frac{qd}{mg\sqrt{l^2 - d^2}}$
   (D) $\frac{qd}{mg}\sqrt{l^2 - d^2}$

10. Find the potential difference between the plates of the capacitor C in the circuit shown. The internal resistance of the sources are negligible—



    (A) − 2 volt (B) + 1 volt
    (C) + 2 volt (D) − 1 volt

11. A loop of flexible conducting wire of length 0·5 m lies in a magnetic field of 1·0 tesla perpendicular to the plane of the loop. When current is passed through the loop it opens into a circle. The tension developed in the wire if the current is of 1·57 amp is—
    (A) 1·25 newton
    (B) 0·125 newton
    (C) 2·93 newton
    (D) 0·293 newton

12. A glass cube of edge 1 cm and μ = 1·5 has a small spot at the centre. What parts of the cube face must be covered to prevent the spot from being seen, no matter what the direction of viewing ? Neglect the case of internal reflection—
    (A) With a circular path of radius 0·45 cm
    (B) With a square of side 1 cm
    (C) It can not be covered
    (D) None of the above

13. Four independent waves are expressed as—

(i) $y_1 = a_1 \sin \omega t$

(ii) $y_2 = a_2 \sin 2\omega t$

(iii) $y_3 = a_3 \cos \omega t$

(iv) $y_4 = a_4 \sin (\omega t + \pi/3)$

The interference is possible between—

(A) (i) and (iii)

(B) (i) and (iv)

(C) (iii) and (iv)

(D) Not possible at all

14. The nuclear radius of a nucleus with nucleon number 10 is 3×10^{-15} metre. Then the nuclear radius of a nucleus with nucleon number 80 is—

(A) 3×10^{-15} metre

(B) $1{\cdot}5 \times 10^{-15}$ metre

(C) 6×10^{-15} metre

(D) $4{\cdot}5 \times 10^{-15}$ metre

15. Energy levels A, B, C of a certain atom correspond to increasing values of energy *i.e.*, $E_A < E_B < E_C$. If λ_1, λ_2, λ_3 are the wavelengths of the radiation corresponding to the transition C to B, B to A and C to A respectively, which of the following relations is correct ?

(A) $\lambda_3 = \lambda_1 + \lambda_2$

(B) $\lambda_3 = \dfrac{\lambda_1 \lambda_2}{\lambda_1 + \lambda_2}$

(C) $\lambda_1 + \lambda_2 + \lambda_3 = 0$

(D) $\lambda_3^2 = \lambda_1^2 + \lambda_2^2$

ANSWERS WITH HINTS

1. (B) 2. (C) 3. (A) 4. (B) 5. (D)
6. (A) 7. (B) 8. (C) 9. (A) 10. (D)
11. (B) 12. (A) 13. (D) 14. (C) 15. (B)

1. Let s be the distance between two spots. Now assume that the velocity of the motor boat in still water is v and the velocity of flow of water is u.

For downward journey

$$\frac{s}{t_1} = v + u \quad \ldots(1)$$

For upward journey

$$\frac{s}{t_2} = v - u \quad \ldots(2)$$

Adding equations (1) and (2), we have

$$\frac{s}{t_1} + \frac{s}{t_2} = 2v$$

or, $$\frac{s(t_1 + t_2)}{t_1 t_2} = 2v$$

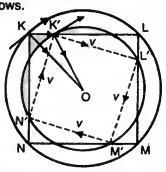
or, $$\frac{s}{v} = \frac{2t_1 t_2}{(t_1 + t_2)}$$

But $$t = \frac{s}{v} = \frac{2t_1 t_2}{(t_1 + t_2)}$$

$$= \frac{2 \times 8 \times 12}{(8 + 12)}$$

$$= 9{\cdot}6 \text{ hr}$$

2. In the square drawn with thick line and dotted line, the four persons are shown moving directly towards the next. In accordance with the problem, speed v of person K is along KL (at $t = 0$) its two components, one along KO of value $v \cos 45°$ *i.e.*, $v/\sqrt{2}$ and other at right angles to KO, incidently of the same value $v/\sqrt{2}$, are also shown in the figure by the dotted arrows.



A little letter K′ is the new position of K, his speed same v (by the problem given uniform) now points along K′L′ and its two components one along K′O and other at right angles to it (shown by dotted curves) each again has value $v/\sqrt{2}$. Similar results follow for other persons L, M, N.

Components towards O will bring them closer and closer to O, till they meet at O, while the other component gives them motion along the circle of shrinking radius. Time taken by the two components on their respective paths from start upto the moment they meet at O are equal.

Now, the distance covered with speed $v/\sqrt{2}$ is equal to KO $(= d/\sqrt{2}$, where d is the side KL of the square)

Hence, time taken till they meet at O,

$$t = \frac{d/\sqrt{2}}{v/\sqrt{2}} = \frac{d}{v}$$

3. Let m be the mass of the ball. When the ball comes down to B, it loses its potential energy mgh which is converted into kinetic energy.

Let v_B be the velocity of the ball at B.

Then $$mgh = \frac{1}{2} m v_B^2 \quad \ldots(1)$$

The ball now rises to a point D, where its potential energy is $mg(h - 2r)$. If v_D be the velocity of the ball at D, then

$$mg(h - 2r) = \frac{1}{2} m v_D^2 \quad \ldots(2)$$

Now to complete the circular path, it is necessary that the centripetal force acting at point D should be equal to or greater than the force mg acting downward.

Therefore,

$$\frac{m v_D^2}{r} \geq mg$$

or, $$v_D^2 \geq rg \quad \ldots(3)$$

From equation (2),

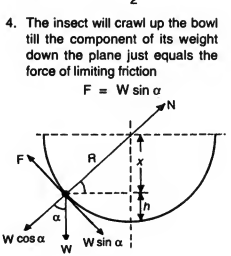
$$v_D^2 = 2g(h - 2r)$$

$$\therefore 2g(h - 2r) \geq rg$$

or, $$h \geq \frac{5}{2} r$$

4. The insect will crawl up the bowl till the component of its weight down the plane just equals the force of limiting friction

$$F = W \sin \alpha$$



and $N = W\cos\alpha$

$\mu = \tan\alpha$

$= F/N = 1/3$

But $\tan(\pi/2 - \alpha) = \cot\alpha$

$= \dfrac{x}{\sqrt{R^2 - x^2}}$

$= 3$

so that $x = 3R/\sqrt{10}$

$= 0{\cdot}949\,R$

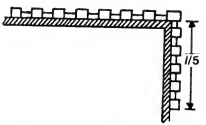
Now $h = R - x$

$= 0{\cdot}051\,R$

5. Mass of the hanging part of the chain

$= m/5$

The weight $mg/5$ acts at the centre of the gravity of the hanging chain, *i.e.*, at the distance = $l/10$ below the surface of the table.



The gain in potential energy in pulling the hanging part on the table,

$$U = \frac{mg}{5} \times \frac{l}{10}$$

$$= \frac{mgl}{50}$$

$\therefore$ Work done

$$U = \frac{mgl}{50}$$

6. Young's modulus

$$Y = \frac{F/A}{l/L} = \frac{FL}{lA}$$

or, $\dfrac{F}{A} = \dfrac{Y l}{L}$

$$= \frac{9 \times 10^{11} \times 0{\cdot}05}{100}$$

$= 45 \times 10^7$ dyne/cm^2

or, $\dfrac{F}{A} = 45 \times 10^7$ ...(1)

The fundamental frequency of transverse vibration of the wire is given by

$$n = \frac{1}{2L}\sqrt{\frac{F}{m}}$$

where,

m = mass per unit length of the wire

= area of cross-section $\times$ density

$= 9$ A

$$\therefore\ n = \frac{1}{2 \times 100{\cdot}05}\sqrt{\frac{F}{9A}}$$

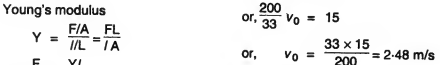
Putting value of F/A from equation (1),

$$n = \frac{1}{2 \times 100{\cdot}05}\sqrt{\frac{45 \times 10^7}{9}}$$

$= 35{\cdot}3$ Hz

7. The situation is shown in the figure. The frequency of the first source heard by the observer is given by

$$n' = 1000\,\frac{330 - v_0}{330} \quad ...(1)$$



The frequency of the second source as heard by the observer is

$$n'' = 100\,\frac{330 + v_0}{330} \quad ...(2)$$

From equation (1) and (2), we get

$$n'' - n' = \frac{1000}{330}[330 + v_0 - 330 + v_0]$$

$$= \frac{1000}{330} \times 2v_0$$

$$= \frac{200}{33}\,v_0$$

But it is given that

$n'' - n' = 15$

or, $\dfrac{200}{33}\,v_0 = 15$

or, $v_0 = \dfrac{33 \times 15}{200} = 2{\cdot}48$ m/s

8. The pressure of the gas P in the jar at T K,

= (Total pressure – saturated vapour pressure)

$= (830 - 30)$

$= 800$ mm of Hg

When the temperature is reduced by 1%, the new temperature

$$T_1 = \left(T - \frac{T}{100}\right)$$

$$= \frac{99}{100}\,T$$

Let the new pressure become P_1.

Applying Charle's law

$$\frac{P}{T} = \frac{P_1}{T_1}$$ we have,

$$\therefore\ P_1 = \frac{PT_1}{T}$$

$$= \frac{800 \times 99T}{100T}$$

$= 792$ mm of Hg

Now saturated vapour pressure at T_1

$= 25$ mm of Hg

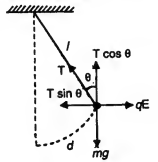
$\therefore$ Total pressure in the jar

= Actual pressure due to gas + saturated vapour pressure

$= 792 + 25$

$= 817$ mm of Hg.

9. In equilibrium, the following forces act on the ball



(i) weight mg acting vertically downward

(ii) tension T in the thread

(iii) electric force q E horizontally to the right

From figure

$T \sin\theta = qE$

and $T\cos\theta = mg$

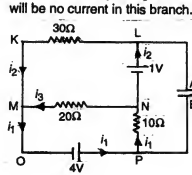
$$\therefore\ \tan\theta = \frac{qE}{mg}$$

or, $E = \dfrac{mg}{q}\tan\theta$

But, $\tan\theta = \dfrac{d}{\sqrt{l^2 - d^2}}$

$$\therefore\ E = \frac{mg}{q}\,\frac{d}{\sqrt{l^2 - d^2}}$$

10. The current distribution is shown in the figure. When the condenser has been fully charged, there will be no current in this branch.



Applying Kirchhoff's first law at junction M

$$i_1 + i_2 = i_3 \quad \ldots(1)$$

Applying Kirchhoff's second law to meshes NLKMN and PNMOP we have

$$30i_2 - 20i_3 = 1 \quad \ldots(2)$$

and $10i_1 + 20\ i_3 = 4 \quad \ldots(3)$

Solving (1), (2) and (3) we get

$$i_2 = i_3 = \frac{1}{10} \text{ amp}$$

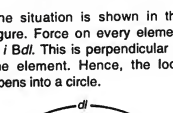
and $$i_1 = \frac{1}{5} \text{ amp}$$

Considering the mesh PBALP, we have

$$V_{AB} - 1 = -10i_1 = -10 \times \frac{1}{5} = -2$$

$$\therefore \quad V_{AB} = -2 + 1 = -1 \text{ volt}$$

11. The situation is shown in the figure. Force on every element = $i\,B\,dl$. This is perpendicular to the element. Hence, the loop opens into a circle.



Now $2T \sin \alpha/2 = i\,B\,dl$

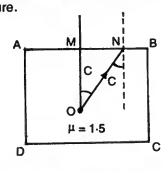
or, $T\alpha = i\,B\,dl$

(Since $\sin \alpha/2 = \alpha/2$)

or, $$T = \frac{i\,B\,dl}{\alpha} = i\,B\,r \quad \left(\text{Since } \frac{dl}{r} = \alpha\right)$$

$$\therefore \quad T = \frac{i\,B\,l}{2\pi} = \frac{1{\cdot}57 \times 1{\cdot}0 \times 0{\cdot}5}{2 \times 3{\cdot}14} = 0{\cdot}125 \text{ newton}$$

12. Let ON be the ray which is just totally reflected as shown in the figure.



$\therefore \quad \angle MON$ = critical angle C

In ΔOMN,

$$\tan C = \frac{MN}{MO} \quad \ldots(1)$$

Again $$\sin C = \frac{1}{\mu} = \frac{2}{3}$$

$$\therefore \quad \cos C = \sqrt{1 - \frac{4}{9}} = \frac{\sqrt{5}}{3}$$

Now $$\tan C = \left(\frac{2}{\sqrt{5}}\right) \quad \ldots(2)$$

From equation (1) and (2), we have,

$$MN = MO \times \tan C = 0{\cdot}5 \times \frac{2}{\sqrt{5}} = 0{\cdot}45 \text{ cm}$$

We have to cover a circular path on each edge with M as centre and 0·45 cm as the radius.

13. Here, the sources are not coherent. *i.e.*, they are independent of each other.

14. $$R \propto (A)^{1/3}$$

$$\therefore \quad \frac{R_{80}}{R_{10}} = \left(\frac{80}{10}\right)^{1/3}$$

$$\therefore \quad R_{80} = 2\,R_{10} = 2 \times 3 \times 10^{-15} = 6 \times 10^{-15} \text{ m}$$

15. $$\frac{1}{\lambda} \propto (E_2 - E_1)$$

$$\therefore \quad \frac{1}{\lambda_1} \propto (E_C - E_B)$$

$$\frac{1}{\lambda_2} \propto (E_B - E_A)$$

$$\frac{1}{\lambda_3} \propto (E_C - E_A)$$

and $E_C - E_A = (E_C - E_B) + (E_B - E_A)$

$$\frac{1}{\lambda_3} = \frac{1}{\lambda_1} + \frac{1}{\lambda_2}$$

or, $$\frac{1}{\lambda_3} = \frac{\lambda_1 + \lambda_2}{\lambda_1 \lambda_2}$$

$$\therefore \quad \lambda_3 = \frac{\lambda_1 \lambda_2}{\lambda_1 + \lambda_2}$$

●●●

(Continued from Page 1728)

$$\left(\frac{41}{28}\right)^2 = \frac{\lambda_{Cu}}{0{\cdot}71}$$

$$\therefore \quad \lambda_{Cu} = 0{\cdot}71 \left(\frac{41}{28}\right)^2 = 1{\cdot}52 \text{ Å}$$

5. In a coolidge tube electrons emitted by the filament strike the target only during one half-cycle of the alternating potential difference *i.e.*, only when the target is positive with respect to the filament. During the other half, target becomes negative with respect to the filament and the electrons are repelled by the target. Thus, the tube acts as its own rectifier.

7. In case of voltage being 40 kV, υ for X-rays will be maximum. Hence, wavelength will be minimum.

10. Energy of X-ray photon is less than that of gamma ray photon. Hence, $\lambda_1 > \lambda_2$.

11. Penetrating power depends on energy $h\,\upsilon$ of X-ray photons.

12. X-rays, like light, are electromagnetic waves and remain undeflected in a magnetic or an electric field.

14. X-rays are electromagnetic waves travelling with velocity of light

15. From Bragg's law

$$\lambda = 2d \sin \theta$$

$$\therefore \quad \lambda_{max} = 2d = 4\text{Å}$$

17. $$\frac{E_1}{E_2} = \frac{hc}{\lambda_1} \times \frac{\lambda_2}{hc} = \frac{\lambda_2}{\lambda_1} = \frac{0{\cdot}5}{0{\cdot}001} = \frac{50}{1}$$

18. $E_{max} = eV$

$= 1{\cdot}6 \times 10^{-19} \times 120 \times 10^3$ joule

$= 1{\cdot}2 \times 10^5$ eV

19. $$\lambda_{min} = \frac{A}{V}$$

where A is a constant.

$\therefore \quad \log \lambda_{min} = \log A - \log V$

This is the equation of a straight line with negative slope.

●●●

LAWS OF MOTION, WORK AND ENERGY

- Inertial mass $m = \frac{\vec{F}}{\vec{a}}$
- Newton's second law of motion
$$\vec{F} = m\vec{a}$$
- Apparent weight when lift is moving up with acceleration
$$R = m(g + a)$$
- Apparent weight when lift is moving down with acceleration
$$R = m(g - a)$$
- Momentum $\vec{P} = m\vec{v}$
- Impulse $= \vec{F} \times \Delta t$
- Acceleration of rocket in earth's influence
$$\vec{a} = \frac{V_r}{m}\left(\frac{\Delta m}{\Delta t}\right) - g$$
- Acceleration of rocket in outer space
$$\vec{a} = \frac{V_r}{m}\left(\frac{\Delta m}{\Delta t}\right)$$
- Work $W = \vec{F} \cdot \vec{d}$
- Kinetic energy $= \frac{1}{2}mv^2$
- Potential energy $= mgh$
- For an elastic spring, the restoring force
$$F = -kx$$
- Potential energy stored in a spring
$$U = \frac{1}{2}kx^2$$

OBJECTIVE QUESTIONS

1. A block of mass M is pulled along a horizontal frictionless surface by a rope of mass m. If a force P is applied at the free end of the rope, the force exerted by the rope on the block will be—
(A) P (B) $\frac{Pm}{M+m}$
(C) $\frac{PM}{M+m}$ (D) $\frac{Pm}{M-m}$

2. A ship of mass 3×10^7 kg initially at rest in water is pulled by a force of 5×10^4 N through a distance of 3m. Assume that the resistance due to water is negligible, the speed of the ship is—
(A) 1·5 m/s (B) 60 m/s
(C) 0·1 m/s (D) 5 m/s

3. A body of mass 2 kg has an initial velocity of 3 m/s along OE and it is subjected to a force of 4N in a direction perpendicular to OE. The distance of the body from O after 4 seconds will be—
(A) 12 m (B) 20 m
(C) 8 m (D) 48 m

4. A thief stole a box full of valuable articles of weight w and while carrying it on his back, he jumped down a wall of height 'h' from the ground. Before he reached the ground he experienced a load of—
(A) $2w$ (B) w
(C) $w/2$ (D) Zero

5. An elevator weighing 6000 kg is pulled upward by a cable with an acceleration of 5 ms^{-2}. Taking g to be 10 ms^{-2}, the tension in the cable is—
(A) 6000 N (B) 9000 N
(C) 60000 N (D) 90000 N

6. Three solids of masses m_1, m_2 and m_3 are connected with weightless string in succession and are placed on a frictionless table. If the mass m_3 is dragged with a force T, the tension in the string between m_2 and m_3 is→
(A) $\frac{m_2}{m_1+m_2+m_3}T$
(B) $\frac{m_3}{m_1+m_2+m_3}T$
(C) $\frac{m_1+m_2}{m_1+m_2+m_3}T$
(D) $\frac{m_2+m_3}{m_1+m_2+m_3}T$

7. In a rocket of mass 1000 kg fuel is consumed at a rate of 40 kg/s. The velocity of the gases ejected from the rocket is 5×10^4 m/s. The thrust on the rocket is—
(A) 2×10^3 N (B) 5×10^4 N
(C) 2×10^6 N (D) 2×10^9 N

8. The mass of a rocket is 10000 kg. The velocity of the gases escaping from it is 1000 m/s. At what rate should the fuel be burnt so that the rocket may just takes off ?
(A) 9·8 kg/sec
(B) 19·6 kg/sec
(C) 19·6 kg/minute
(D) 98 kg/sec

9. A cricket ball of mass 150 gram moving with a velocity of 12 m/s strikes against the bat. It rebounces with a velocity of 20 m/s. The ball remains in touch with the bat for 0·01 second. The average force applied by the bat on the ball is—
(A) 840 newton
(B) 480 newton
(C) 804 newton
(D) 408 newton

10. Action and reaction act on—
(A) Same body in opposite directions

(B) Same body in the same direction
(C) Different bodies in opposite directions
(D) Different bodies but in the same direction

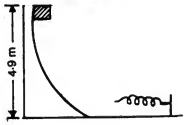
11. An object lying on a horizontal table is pulled by applying a force equal to 100 newton. The direction of force makes an angle of 60° with the horizontal. The work done in pulling the object by 10 metre will be—
(A) 1000 joule (B) 500 joule
(C) 250 joule (D) 125 joule

12. A diesel engine lifts 50 kg. water from depth of 5 metre in 100 second. Its power shall be— ($g = 10\ m/s^2$)
(A) 50 watt (B) 25 watt
(C) 100 watt (D) 200 watt

13. If the kinetic energy of a body is increased by 300%, the increase in the momentum of the body will be—
(A) 400% (B) 200%
(C) 100% (D) 50%

14. A block of mass m, attached to a spring of spring constant k, oscillates on a smooth horizontal table. The other end of the spring is fixed to a wall. If it has a speed v when the spring is at its natural length, how far will it move on the table before coming to an instantaneous rest—
(A) $\sqrt{\frac{vm}{k}}$ (B) $\sqrt{\frac{v\,k}{m}}$
(C) $v\sqrt{\frac{k}{m}}$ (D) $v\sqrt{\frac{m}{k}}$

15. Figures shows a smooth curved track terminating in a smooth horizontal part. A spring of spring constant 400 N/m is attached at one end to a wedge fixed rigidly with the horizontal part. A 40 g mass is released from rest at a height of 4·9 m on the curved track. The maximum compression of the spring is—



(A) 9·8 cm (B) 98 cm
(C) 9·8 m (D) 8·9 m

16. A particle moves under the effect of a force $F = Cx$ from $x = 0$ to $x = x_1$. The work done in the process is—
(A) Cx_1^2 (B) $\frac{1}{2}Cx_1^2$
(C) Cx_1 (D) Zero

17. A lead ball falling freely from a height strikes the ground. As a result its temperature rises. This is due to—
(A) Friction due to air
(B) Conversion of mass into heat
(C) Conversion of chemical energy into heat
(D) Conversion of mechanical energy into heat

18. It is easier to draw up wooden block along an inclined plane than have it up vertically, principally because—
(A) The friction is reduced
(B) The mass becomes smaller
(C) Only a part of weight has to be overcome
(D) g becomes smaller

ANSWERS

1. (C) 2. (C) 3. (B) 4. (D) 5. (D)
6. (C) 7. (C) 8. (D) 9. (B) 10. (C)
11. (B) 12. (B) 13. (C) 14. (D) 15. (A)
16. (B) 17. (D) 18. (C)

HINTS

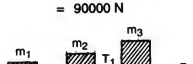
1. Acceleration of the system
$$= \frac{P}{m+M}$$
The force exerted by the rope on the mass
$$= \frac{MP}{m+M}$$

2. Acceleration $= a$
$$= \frac{5\times10^4}{3\times10^7}$$
$$v = \sqrt{2as}$$
$$= \sqrt{\frac{2\times5\times10^4}{3\times10^7}\times3}$$
$$= \sqrt{\frac{10^4}{10^6}} = 0{\cdot}1\ m/s$$

3. Acceleration
$$= a = \frac{4}{2} = 2\ m/s^2$$
a is zero in direction OE.
Displacement along OE in 4 sec
$$= s_1$$
$$= ut = 3\times4 = 12\ m$$
Initial velocity along the direction of force = 0.
Displacement along the direction of force
$$= s_2 = \frac{1}{2}at^2$$
$$= \frac{1}{2}\times2\times4^2$$
$$= 16$$
$\therefore$ Resultant displacement
$$= \sqrt{s_1^2 + s_2^2}$$
$$= \sqrt{12^2 + 16^2}$$
$$= 20\ m$$

4. A freely falling body does not experience any load.

5. Tension in this case is equal to apparent weight.
$$T = m(g + a)$$
$$= 6000\ (10 + 5)$$
$$= 90000\ N$$

6. 

Acceleration of the whole system
$$a = \frac{T}{m_1 + m_2 + m_3}$$
Required Tension
$$= (m_1 + m_2)\times a$$
$$= \frac{(m_1 + m_2)T}{(m_1 + m_2 + m_3)}$$

7. Thrust $= 5\times10^4\times40$
$$= 2\times10^6\ N$$

8. The force required to take off must be equal to the weight of the rocket.
$$F = v_r\left(\frac{\Delta m}{\Delta t}\right) = mg$$
$$\frac{\Delta m}{\Delta t} = \frac{mg}{v_r}$$
$$= \frac{10000\times9{\cdot}8}{1000}$$
$$= 98\ kg/sec.$$

(Continued on Page 1813)

CLASSIFICATION AND NOMENCLATURE OF ORGANIC COMPOUNDS

Organic Compounds

For more than 200 years, chemists divided the materials into two categories. Those isolated from plants and animals were classified as organic, while those extracted from minerals were known as inorganic. At one time chemists believed that organic compounds were fundamentally different from inorganic, because organic compounds contained a **vital force** that was only found in living systems.

The synthesis of urea from inorganic starting material by **Friederich Wohler** marked the first step in the decline of **vital force theory**.

$$\underset{\text{Silver cyanate}}{AgOCN_{(aq)}} + NH_4Cl_{(aq)} \longrightarrow AgCl_{(s)} + \underset{\text{Amm. cyanate}}{NH_4OCN_{(aq)}}$$

$$NH_4OCN \xrightarrow{\Delta} \underset{\text{Urea}}{NH_2CONH_2}$$

The synthesis of urea from inorganic material, inevitably led to the removal of vitalism from the list of theories. If the difference between organic and inorganic compounds is not the presence of some mysterious vital forces, required for their synthesis, what is the basis for distinguishing between these two classes of compounds ? Most compounds extracted from living organisms contain carbon. It is, therefore, tempting to identify organic chemistry as the chemistry of carbon. But this definition includes compounds such as calcium carbonate ($CaCO_3$), as well as elemental form of carbon such as graphite and diamond are clearly inorganic. Therefore, perhaps the best definition identifies organic chemistry as the chemistry of compounds that contains both carbon and hydrogen.

Several years ago an unmanned **Viking spacecraft** carried out experiments designed to search for evidence of life on **Mars.** These experiments were based on the assumption that living systems contain carbon and the absence of any evidence for carbon-based life on that planet was assumed to mean that no life existed. Several factors make the carbon essential for life.

(i) The ease with which it forms bonds to itself *i.e.*, it shows the inordinate tendency for **catenation.**

(ii) Its tendency to form **multiple bonds** to N, O, P and S atoms.

(iii) Bonds formed by carbon are considerably strong.

These factors provide an utmost infinite variety of potential structures for organic compounds. No other element can provide the variety of combinations and permutations necessary for life to exist.

Classification of Organic Compounds

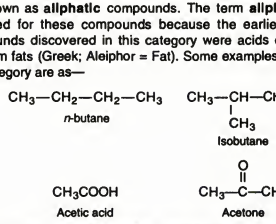
For convenient and for systematic study organic compounds are divided into two main groups—

(1) Aliphatic or Open chain compounds.

(2) Cyclic or Closed chain compounds.

1. Aliphatic or Open chain compounds

These are the organic compounds which contain open chain of carbon atoms. All such compounds are known as **aliphatic** compounds. The term **aliphatic** is used for these compounds because the earlier compounds discovered in this category were acids derived from fats (Greek; Aleiphor = Fat). Some examples of this category are as—



2. Cyclic or Closed chain compounds

These organic compounds contain at least one ring or closed chain of atoms. Depending upon the structure and the composition of ring, these compounds are further divided into two categories—

(A) Homocyclic or Carbocyclic Compounds

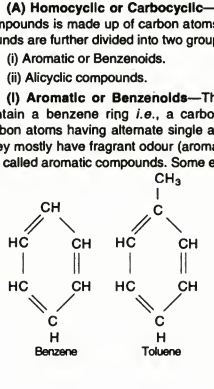
(B) Heterocyclic Compounds

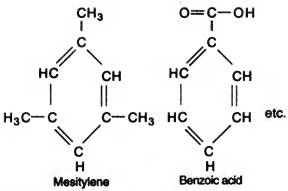
(A) Homocyclic or Carbocyclic—The ring in these compounds is made up of carbon atoms only. Such compounds are further divided into two groups—

(i) Aromatic or Benzenoids.

(ii) Alicyclic compounds.

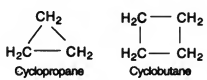
(I) Aromatic or Benzenoids—These compounds contain a benzene ring *i.e.*, a carbocyclic ring of six carbon atoms having alternate single and double bonds. They mostly have fragrant odour (aroma) and hence they are called aromatic compounds. Some examples are as—

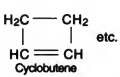




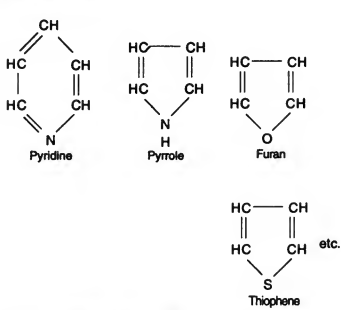
(ii) Alicyclic compounds—These compounds are also homocyclic *i.e.,* they have identical atoms in the ring but they do not have benzene ring. The properties of these compounds resemble more with aliphatic compounds. Therefore, the term **alicyclic** (cyclic compounds with aliphatic properties) is used for such compounds.

Some examples of alicyclic compounds are as—

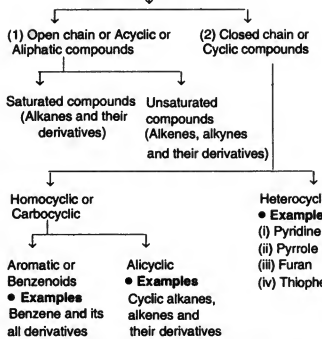




(B) Heterocyclic—These are also cyclic compounds but the ring in these compounds is made up of more than one kind of atoms. As the rings in organic compounds are mainly due to carbon atoms, the atoms other than carbon atoms present in the ring are known as **heteroatoms**. Nitrogen, oxygen and sulphur are some main heteroatoms present in heterocyclic compounds. Some familiar examples are as—



Organic Compounds
(Classification at a glance)



Classification of Aliphatic Compounds and Homologous Series

Many organic compounds resemble each other in their chemical properties and have identical constitution. On account of this they have been grouped in various classes or families, each having a common functional group and is known as a **Homologous Series** and members are said to be homologues.

Thus, homologous series may be defined as a class or a group of organic compounds with similar constitution having a common functional group with similar chemical properties and a graded set of physical properties.

Following are characteristics of a homologous series–

(a) All the members of a particular homologous series are represented by same general formula. For example—

Homologous Series	General Formula
Alkanes	C_nH_{2n+2}
Alkenes	C_nH_{2n}
Alkynes	C_nH_{2n-2}
Alcohols	$C_nH_{2n+1}OH$ etc.

(b) Each member of a homologous series is known as **homologue** and differs from its preceding and succeeding members by $—CH_2—$. Thus, there is a constant difference of CH_2 between the molecular formulae of two consecutive members.

(c) All the members of a homologous series can be prepared by same general methods of preparation.

(d) Due to the presence of same functional group all the members of a homologous series have similar chemical properties.

(e) Physical properties like solubility, melting and boiling points of a homologous series register a gradual change. They increase as one moves from lower to higher members in a series.

According to the **group** in a particular homologous series, the aliphatic organic compounds are classified as—

Compounds having functional groups with or without Oxygen

Name of Group	Formula	Class of Compounds
Alkyl	C_nH_{2n+1} or R—	Alkanes or Paraffins
Alkenyl	C_nH_{2n-1}	Alkenes or Olefins
Alkynyl	C_nH_{2n-3}	Alkynes or Acetylenes
Alcoholic	—OH	Alcohols (R—OH)
Halo-	—X	Alkyl halides (R—X)
Ether	—O—	Ethers (R—O—R)
Aldehydic	—CHO	Aldehydes $\left(\begin{matrix}O\\ \|\|\\ R-C-H\end{matrix}\right)$
Ketonic	—CO—	Ketones $\left(\begin{matrix}O\\ \|\|\\ R-C-R\end{matrix}\right)$
Carboxylic	$\begin{matrix}O\\ \|\|\\ -C-OH\end{matrix}$	Carboxylic acids $\left(\begin{matrix}O\\ \|\|\\ R-C-OH\end{matrix}\right)$
Ester	$\begin{matrix}O\\ \|\|\\ -C-OR'\end{matrix}$	Esters $\left(\begin{matrix}O\\ \|\|\\ R-C-OR'\end{matrix}\right)$

Functional groups containing Nitrogen or Sulphur

Name of Group	Formula	Class of Compounds
Amino	$-NH_2$	Amines (R—NH_2)
Amide	$-CONH_2$	Amides (R—$CONH_2$)
Nitro	$-N\begin{matrix}O\\ \diagdown\\ \diagup\\ O\end{matrix}$ (—NO_2)	Nitro Compounds (R—NO_2)
Nitrite	—O—N = O	Nitrites (R—O—N = O)
Nitrile or Cyanide	—C≡N	Nitriles or Cyanides (R—CN)
Isonitrile or Isocyanide	—N ⇉ C	Isonitriles or Isocyanides (R—NC)
Thioethers	—S—	Thioethers (R—S—R)
Thioalcoholic	—SH	Thioalcohols or mercaptans (R—SH)

Nomenclature of Organic Compounds

Trivial or Common System

In the earlier times, when the number of organic compounds was limited, they used to be named according to the source or on the basis of their special characteristic. For example—

(i) CH_4 is known as **marsh gas** as it is found at marshy places.

(ii) CH_3OH is known **wood spirit** as it is obtained by destructive distillation of **wood.**

(iii) CH_3COOH is known as acetic acid as it is obtained from **vinegar (Latin name acetum).**

(iv) HCOOH is known as **formic acid** as its main source is **formica** (ants).

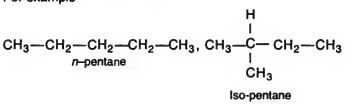
(v) CH_3CH (OH) COOH is known as **lactic acid,** as it is found in milk (Lactum).

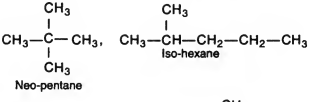
(vi) $\begin{matrix}CHOHCOOH\\ |\\ CH_2COOH\end{matrix}$ is known as **malic acid** as it is found in pyrus malus (apple).

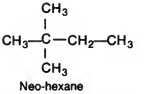
(vii) NH_2CONH_2 is known as **urea,** as it is found in urine.

In the **paraffin series** (saturated hydrocarbons) first four members *viz.*, methane, ethane, propane and butane are so named after the names of corresponding alcohols. The next higher members are named according to the Greek numerals indicating the number of carbon atoms with the suffix—ane. According to this system straight chain hydrocarbons are called **normal** (abbreviated as *n*–) and branched chain hydrocarbons containing a tertiary carbon atom are called **Iso** and those having a quaternary carbon atom are called **neo.**

For example—







The various isomers of hexane and higher alkanes cannot be differentiated by using prefixes *n*, iso and neo. This is due to the reason that with increase in number of carbon atoms, the number of isomers increases rapidly.

Common or Trivial names of compounds of various families are enlisted below—

Alkenes or Olefins :

Molecular formula	Common or Trivial name
$CH_2=CH_2$	Ethylene
$CH_3-CH=CH_2$	Propylene
$CH_3-CH=CH-CH_3$	β-butylene
$\begin{matrix}CH_3\\ \diagdown\\ \diagup\\ CH_3\end{matrix}C=CH_2$	Iso-butylene
$CH_2=C=CH_2$	Allene

Alkynes or Acetylenes :

$CH \equiv CH$	Acetylene
$CH_3-C \equiv CH$	Methylacetylene (Allylene)
$CH_3-CH_2-C \equiv CH$	Ethylacetylene
$CH_3-C \equiv C-CH_3$	Dimethylacetylene (Crotonylene)

Halides :

CH_3Cl	Methyl chloride
CH_3CH_2Cl	Ethyl chloride
$CH_2=CH-Cl$	Vinyl chloride
$CH_2=CH-CH_2-Br$	Allyl bromide
$CH_3-\underset{\displaystyle CH_3}{\overset{\displaystyle |}{CH}}-Cl$	Iso-propyl chloride

Alcohols :

CH_3OH	Methyl alcohol (Carbinol)
$CH_3-\underset{\displaystyle CH_3}{\overset{\displaystyle |}{CH}}\cdot OH$	Dimethyl carbinol
$CH_3-CH_2\cdot OH$	Ethyl alcohol
$CH_3-CH_2-CH_2\cdot OH$	*n*–propyl alcohol
$CH_3-CH_2-CH_2-CH_2\cdot OH$	*n*–butyl alcohol
$CH_3-CH_2-CH_2-CH_2\cdot CH_2OH$	*n*–amyl alcohol or *n*–pentyl alcohol
$\begin{matrix} CH_3 \\ \diagdown \\ \quad CH \\ \diagup \\ CH_3 \end{matrix}-CH_2-OH$	Iso-butyl alcohol
$CH_2=CH-OH$	Vinyl alcohol
$CH_2=CH-CH_2OH$	Allyl alcohol
$CH \equiv C-CH_2-OH$	Propargyl alcohol

Aldehydes :

$HCHO$	Formaldehyde
CH_3CHO	Acetaldehyde
CH_3-CH_2-CHO	Propionaldehyde
$CH_3-CH_2-CH_2-CHO$	*n*–butyraldehyde
$CH_3-CH_2-CH_2-CH_2-CHO$	*n*–valeraldehyde
$\begin{matrix} CH_3 \\ \diagdown \\ \quad CH \\ \diagup \\ CH_3 \end{matrix}-CHO$	Iso-butyraldehyde
$CH_2=CH-CHO$	Acrolein
$CH_3-CH=CH-CHO$	Crotonaldehyde

Ketones :

CH_3COCH_3	Dimethyl ketone or Acetone
$CH_3COCH_2-CH_3$	Ethylmethyl ketone
$CH_3COCH=CH_2$	Methyl vinyl ketone

Carboxylic Acids :

$HCOOH$	Formic acid
CH_3-COOH	Acetic acid
CH_3-CH_2-COOH	Propionic acid
$CH_3-CH_2-CH_2-CH_2-COOH$	*n*–valeric acid
$CH_3-CH_2-CH_2-COOH$	*n*–butyric acid
$\begin{matrix} CH_3 \\ \diagdown \\ \quad CH \\ \diagup \\ CH_3 \end{matrix}-COOH$	Iso-butyric acid
$CH_2=CH-COOH$	Acrylic acid
$CH_3-\overset{\displaystyle O}{\overset{\displaystyle \|}{C}}-COOH$	Pyruvic acid

Ethers :

CH_3-O-CH_3	Dimethyl ether
$CH_3-O-CH_2-CH_3$	Ethylmethyl ether
$CH_3-CH_2-O-CH_2-CH_3$	Diethyl ether
$\begin{matrix} CH_3 \\ \diagdown \\ \quad CH \\ \diagup \\ CH_3 \end{matrix}-O-\begin{matrix} \diagup \\ CH \\ \diagdown \\ CH_3 \end{matrix}$	Di-isopropyl ether
$CH_2=CH-O-CH_2-CH=CH_2$	Allyl vinyl ether

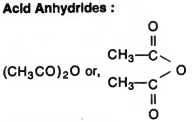
Esters :

$H-\overset{\displaystyle O}{\overset{\displaystyle \|}{C}}-OCH_3$	Methyl formate
$CH_3-\overset{\displaystyle O}{\overset{\displaystyle \|}{C}}-OCH_3$	Methyl acetate
$CH_3-CH_2-\overset{\displaystyle O}{\overset{\displaystyle \|}{C}}-OCH_3$	Methyl propionate
$CH_3CH_2CH_2CH_2-\overset{\displaystyle O}{\overset{\displaystyle \|}{C}}-OC_2H_5$	Ethyl valerate

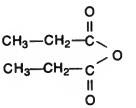
Acid Chlorides :

$HCOCl$	Formyl chloride
CH_3COCl	Acetyl chloride
CH_3CH_2COCl	Propionyl chloride

Acid Anhydrides :

$(CH_3CO)_2O$ or, 	Acetic anhydride
$(CH_3CH_2CO)_2O$	Propionic anhydride

or



Primary Amines :

CH_3NH_2	Methylamine
$CH_3CH_2NH_2$	Ethylamine
$CH_3—CH_2—CH_2NH_2$	*n*–propylamine

Secondary Amines :

$CH_3—NH—CH_3$	Dimethylamine
$CH_3CH_2—NH—CH(CH_3)_2$	Ethyl isopropylamine

Tertiary Amines :

$(CH_3)_3N$	Trimethylamine
$(C_2H_5)_2N—CH_3$	Diethylmethylamine

Amides :

$HCONH_2$	Formamide
CH_3CONH_2	Acetamide
$HCON(CH_3)_2$	N, N–Dimethyl formamide (DMF)
$CH_3CON(CH_3)_2$	N, N–Dimethyl acetamide
$CH_2=CH—CONHCH_3$	N–Methyl acrylamide

Cyanides :

CH_3CN	Acetonitrile or Methylcyanide
CH_3CH_2CN	Propionitrile or Ethylcyanide
$CH_3CH_2CH_2CN$	Butyronitrile or Propyl cyanide
$CH_2=CH—CN$	Acrylonitrile
$CH_3—CH=CH—CN$	Crotononitrile
$CH_3—C(CH_3)_2—CN$	Tertiary butyl cyanide

Iso-cyanides :

CH_3NC	Methyl isocyanide
CH_3CH_2NC	Ethyl isocyanide
$CH_2=CH—NC$	Acryloisonitrile
$CH_3—CH=CH—NC$	Crotonoisonitrile

Dihalides :

CH_3CHCl_2	Ethylidene chloride
$CH_3—C(Br)_2—CH_3$	Iso-propylidene bromide
$CH_3—CH(Br)—CH(Br)—CH_3$	Iso-butylidene bromide
CH_2Cl_2	Methylene chloride
$ClCH_2CH_2Cl$	Ethylene chloride
$CH_3—CHCl—CH_2Cl$	Propylene chloride
$Cl—CH_2—CH_2—CH_2Cl$	Trimethylene chloride

Glycols :

$CH_2OH—CH_2OH$	Ethylene glycol
$CH_3—CH(OH)—CH(OH)—CH_2$	Iso-pentylene glycol
$HO—CH_2—CH_2—CH_2—OH$	Trimethylene glycol

Bond Line Notation of Organic Molecules

It is simple, brief and convenient method of representing organic molecules. In these notations the bonds between the carbon atoms are shown by a line. A single line shows a single bond, two parallel lines (=) show a double bond and three parallel lines (≡) represent a triple bond. The intersection of lines shows carbon atoms having appropriate number of hydrogen atoms. Thus, ethane is represented as / but when this symbol (/) is attached to some other molecules then it will represent only methyl group. For example—


is known as methyl cyclopropane.

Likewise—


represents propane but it becomes ethyl group when attached to some other molecules. For example—


is known as ethyl cyclopropane.


represents propene or vinyl group or ethynyl.


represents butane or propyl group.


represents pentane or butyl group.


represents hexane or pentyl group.


represents butadiene and  represents allyl group.

Application of bond line notations in IUPAC system of nomenclature will be discussed in next issue.

Points to Remember

- Some alkyl groups are abbreviated as—
  Methyl (Me)
  Ethyl (Et)
  n–propyl (P_r^n)
  Iso-propyl (P_r^i)
  n–butyl (B^n)
  Iso-butyl (B^i)
  Sec–butyl (B^s)
  Ter-butyl (B^t)
- Camping stoves often use liquid butane and liquid alkane, both normal and isomeric, are the principal components of various petroleum products, such as gasoline, kerosene, fuel oil and diesel oil.
- The alkyl group derived from iso-butane by removing H atom from the central C atom is known as tert. butyl group.
- Butyric acid gives rancid butter its unpleasant odour and the name is related to the Latin word for butter, **butyrum**.
- The names of caproic (C_6) acid as well as caprylic (C_8) and capric (C_{10}) acids, are all derived from the Latin word **caper** for goat, since these acids combine to give goats, their characteristic odour.
- $HOOC—CH_2—CH_2—COOH$ is known as **succinic acid**, it is found in **Fossils, Lichens** and was discovered by Agricola.
- $HOOC—CH_2CH_2CH_2—COOH$ goes by the name **Glutaric acid**. It is found in sugar beets.
- The common name of $CH_2OH—CHOH\,CH_2OH$ is **glycerine** or **glycerol**.
- Until about the middle of the 19th century, it was generally believed that organic compounds were different from other chemical compounds in that organic compounds could be formed only by living organisms and that they contained a 'Vital Force' somehow associated with the life process. This vital force theory was gradually abandoned after 1828 when **Friederich Wohler** found that urea, a compound present in human urine, could be synthesized from purely inorganic salt ammonium cyanate.
- The common name of HOOC—COOH is oxalic acid and it is derived from word **oxalis** *i.e.*, the oxalis family of plants (wood sorrel) contains this acid in the form of salts.
- The common name of the compound having molecular formula $HOOCCH_2\overset{O}{\overset{\|}{C}}COOH$ is **oxaloacetic acid.**
- $CH_3(CH_2)_3\,COOH$ goes by common name *n*–valeric acid as it is obtained from plant **valerian.**
- The common name of $(CH_3)_3C—OH$ is **trimethyl carbinol.**
- Compound  is known as **ethyl cyclohexane**
- and  is known as **isopropyl cyclohexane.**

Some Important Common names to remember

1.		Oxirane or Ethylene oxide or oxocyclopropane
2.	$CH_3COCOOH$	Pyruvic acid
3.	CCl_4	Pyrene
4.	CH_3COCHO	Pyruvaldehyde (Methyl glyoxal)
5.	$CH_3CH(OCH_3)_2$	Methylal
6.	$Cl—CH_2—CH_2—S—CH_2—CH_2Cl$	Mustard gas
7.	$CH_2\,(COOH)_2$	Malonic acid
8.	$(CH_3)_2\,C(OH)\,C(OH)(CH_3)_2$	Pinacol
9.	$(CH_3)_2(COH)CCl_3$	Chloretone
10.	CCl_3CHO	Chloral
11.	$CCl_3CH(OH)_2$	Chloral hydrate
12.	$C(NO_2)\,Cl_3$	Chloropicrin
13.	$CHCl=CH\cdot AsCl_2$	Lewisite
14.	$CHCl_2—CHCl_2$	Westron
15.	$CCl_2=CHCl$	Westrosol
16.	NH_2CONH_2	Carbamide (Urea)

Trivial or Common names of Some Aromatic Compounds—The term aromatic is derived from Greek word **aroma** which means pleasant smelling compounds. The families of aromatic compounds are similar to those of aliphatic compounds. The trivial or common names of some aromatic compounds are given on next page.

Hydrocarbons :

Formula of compound	Common name
	Benzene (in the older American and British literature it is designated as benzol.)
	Toluene
	Styrene
	Mesitylene
	*o*-xylene

Halogen Derivatives :

	Chlorobenzene
	Benzyl chloride
	Benzal chloride
	Benzotrichloride

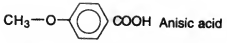
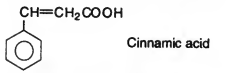
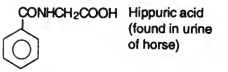
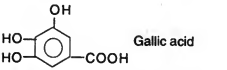
Phenols and Alcohols :

	Phenol or Carbolic acid
	Catechol
	Resorcinol
	Quinol
	Pyrogallol
	Hydroxyquinol
	Phloroglucinol
	*m*–cresol
	Benzyl alcohol
	Picric acid

Aldehydes :

	Salicylaldehyde
	Anisaldehyde

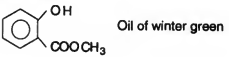
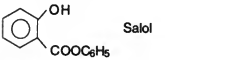
Carboxylic Acids :

	Salicylic acid
	Phthalic acid
	Mandelic acid
	Anisic acid
	Cinnamic acid
	Hippuric acid (found in urine of horse)
	Gallic acid

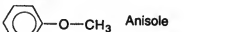
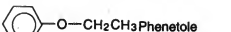
Ketones :

	Acetophenone
	Benzophenone

Esters :

	Oil of winter green
	Salol

Ethers :

	Anisole
	Phenetole

1st Chart of Common name system

1.	R—X	Alkyl halide
2.	R—OH	Alkyl alcohol
3.	R—SH	Alkyl thioalcohol
4.	$R—NH_2$	Alkyl amine
5.	R—CN	Alkyl cyanide
6.	R—NC	Alkyl isocyanide
7.	R—O—R	Dialkyl ether
8.	R—O—R′	Alkyl alkyl′ ether
9.	R—NH—R	Dialkyl amine
	R—NH—R′	Alkyl alkyl′ amine
10.	R—C(=O)—R	Dialkyl ketone
	R—C(=O)—R′	Alkyl alkyl ketone

2nd Chart of Common name system

No. of Carbon Atoms	Common Name	Alde-hyde	Acid	Acid Chloride	Acid amide	Ester	Cyanide	iso-cyanide	Anhydride
									
		or —CHO aldehyde	or —COOH ic acid	or —COCl yl-chloride	or —$CONH_2$ amide	or —COOR ate	or —CN *o*-nitrile	or —NC *o*-isonitrile	or —$(CO)_2O$ ic-anhydride
1 C	Form.	Examples :							
2 C	Acet.								
3 C	Propion.								
4 C	Butyr (*n*, iso, sec, ter)								
5 C	Valer (*n*, iso, sec, ter)								
3 C + (=)	Acryl								
4 C + (=)	Croton								

(a) $CH_3—\underset{\displaystyle CH_3}{\underset{|}{CH}}—CH_2COOH$ — 5 C atoms — Valer is used. Isovaleric acid (As structure belongs to iso group)

(b) $CH_3—CH=CH—COCl$ — 4 C atoms + (=) — Croton is used. Crotonyl chloride

(c) $CH_2=CHCN$ — 3 C atoms + (=) — Acryl is used. Acrylonitrile

(Will continue to next issue.)

OBJECTIVE QUESTIONS

1. Which one of the following is a heterocyclic compound ?
   (A) Methyl cyclobutane
   (B) Cyclohexane
   (C) Pyridine
   (D) Chlorobenzene
2. Alicyclic compounds are—
   (A) Open chain compounds
   (B) Aromatic compounds
   (C) Heterocyclic compounds
   (D) Cyclic aliphatic compounds
3. Which of the following statements is correct ?
   (A) Homocyclic compounds are aromatics
   (B) Homocyclic compounds are aliphatics
   (C) A and B both are correct
   (D) A and B both are wrong
4. Which one of the following is a heteroatom in the furan ?
   (A) Nitrogen
   (B) Sulphur
   (C) Oxygen
   (D) Phosphorus
5. Which of the following acids is found in the fat of goat ?
   (A) Acetic acid
   (B) Capric acid
   (C) Formic acid
   (D) Propionic acid
6. The compound which is present in urine of horse is known as—
   (A) Uric acid
   (B) Hippuric acid
   (C) Glutamic acid
   (D) Oxalic acid
7. The common name of CH_3Cl is—
   (A) Methyl chloride
   (B) Chloromethane
   (C) Methylene chloride
   (D) None of these
8. Which of the following compounds has a quaternary carbon atom ?
   (A) Neo-amyl chloride
   (B) Tert. amyl alcohol
   (C) *n*-butyl chloride
   (D) Iso-amyl chloride
9. Methylene chloride is the common name of—
   (A) $CH_2Cl—CH_2Cl$
   (B) CH_2Cl_2
   (C) $CHCl_3$
   (D) $CH_3—CHCl_2$
10. The common name of pentanoic acid is—
    (A) *n*-valeric acid
    (B) Iso–valeric acid
    (C) *n*-butyric acid
    (D) Butanoic acid
11. Ethylidene chloride is a—
    (A) Gem-dihalide
    (B) Vic-dihalide
    (C) Both A and B
    (D) None of these
12. Which one of the following is not an aromatic compound ?
    (A) *m*-xylene
    (B) Cyclohexane
    (C) Anisole
    (D) Anisaldehyde
13. Which of the following statements is wrong ?
    (A) Homologues have same functional group
    (B) Homologues are isomeric with each other
    (C) Homologues of series have similar characteristic properties

(Continued on Page 1791)

OXIDATION, REDUCTION AND REDOX REACTIONS

Process of Discovery :

The first step towards a theory of chemical reactions was taken by **George Ernst Stahl** in 1697, when he proposed the **phlogiston theory,** which was based on following observations—

- Metals have many properties in common.
- Metals often produce a **calx,** when heated. The calx is the crumbly residue left after a mineral or a metal is roasted.
- These calxes are not as dense as the metals from they are produced.
- Some of these calxes form metals when heated with charcoal.
- With only a few exceptions, the **calxes** are found in nature, not the metal.

These observations led Stahl to the following conclusions—

- **Phlogiston** (From the **Greek Phlogistos,** 'to burn') is given off whenever something burns.
- Wood and charcoal are particularly rich in phlogiston because they leave very little ash when they burn. Candles must be almost pure phlogiston because they leave no ash.
- Metals form a calx by giving off phlogiston.

  Metal → Calx + Phlogiston
- Metals can be made by adding phlogiston to the calx.

  Calx + Phlogiston → Metal
- As charcoal is rich in phlogiston, heating calx in the presence of charcoal, sometimes produces metals.

Initially, there was only one problem with phlogiston theory. As early as 1630, **Jean Rey** noted that tin gains weight when it forms a calx. From this point of view, this seems to be a fatal flaw. If phlogiston is given off when metal forms calx, why does the calx weigh more than a metal.

The phlogiston theory was the basis for research in chemistry for most of the 18th century. It was not until 1772 that Antoine Lavoisier noted that non-metals gain weight when burnt in air. The magnitude of the change led Lavoisier to conclude that phosphorus must combine with something in the air when it burns. This conclusion was reinforced by the observation that the volume of air reduced by a factor of 1/5th when phosphorus burns in a limited amount of air.

Lavoisier proposed the name **Oxygene** (literally, the acid former) for the substance absorbed from the air when a compound burns because the products of combustion of non-metals such as phosphorus are acids when they dissolve in water.

$$P_{4(s)} + 5\,O_{2(g)} \rightarrow P_4O_{10\,(s)}$$

$$P_4O_{10(s)} + 6\,H_2O_{(l)} \rightarrow 4\,H_3PO_{4\,(aq)}$$

Lavoisier's oxygen theory of combustion was eventually accepted and chemists began to describe any reaction between an element or compound and oxygen as **oxidation.**

$$2\,Mg_{(s)} + O_{2(g)} \rightarrow MgO_{(s)}$$

By the turn of the twentieth century, it seemed that all oxidation reactions had one thing in common. Oxidation always seemed to involve the loss of electrons. Chemists, therefore, developed a model for these reactions that focussed on the transfer of electrons. By convention, the element or compound gained the electrons was said to undergo **reduction.**

$$2\,Mg + O_2 \longrightarrow 2\,[Mg^{2+}]\,[O^{2-}]$$

oxidation

reduction

Chemists eventually recognised that oxidation-reduction reactions do not always involve the transfer of electrons. There is no change in the number of valence electrons on any of the atoms in the following reaction—

$$CO_2 + H_2 \longrightarrow CO + H_2O$$

Chemists, therefore, developed the concept of **Oxidation number** to extend the idea of oxidation and reduction to reactions in which electrons are not really gained or lost. Thus,

Oxidation involves increase in the oxidation number of an atom. **Reduction** occurs when the oxidation number of an atom decreases.

Oxidation Process :

(A) When an element or a compound combines with oxygen or any other electronegative atom, the element or the compound is said to be oxidised—

$$2\,Mg + O_2 \rightarrow 2\,MgO$$
$$Mg + Cl_2 \rightarrow MgCl_2$$
$$3\,Mg + N_2 \rightarrow Mg_3N_2$$
$$H_2 + Cl_2 \rightarrow 2\,HCl$$

(B) The removal of hydrogen or any other electropositive element from a substance is known as oxidation of that substance—

$$H_2S + H_2O_2 \rightarrow 2\,H_2O + S$$
$$2\,KI + H_2O_2 \rightarrow 2\,KOH + I_2$$

(C) According to electronic definition, when any atom, molecule or ion loses electrons, they are said to be oxidised. Hence **de-electronation** of any species is called oxidation of that species—

$$Na - e^- \rightarrow Na^+$$
$$Al - 3\,e^- \rightarrow Al^{3+}$$

$$Cl^- - e \rightarrow Cl$$
$$H_2S - 2e^- \rightarrow 2H^+ + S$$
$$Sn^{2+} - 2e^- \rightarrow Sn^{4+}$$
$$Cu^+ - e \rightarrow Cu^{++}$$

(D) When **oxidation number** of any chemical species is increased, the species is said to be oxidised. An increase in oxidation number is a tendency of losing electrons.

Reduction Process :

(A) The attachment of hydrogen or any electropositive atom to any substance is called reduction of that substance—

$$Cl_2 + H_2 \rightarrow 2HCl$$
$$Cl_2 + 2Na \rightarrow 2NaCl$$
$$O_2 + 2H_2 \rightarrow 2H_2O$$
$$N_2 + 3H_2 \rightarrow 2NH_3$$

(B) The removal of oxygen or any other electronegative atom from a substance is called reduction of that substance—

$$2MgO \rightarrow 2Mg + O_2$$
$$2HgO \rightarrow 2Hg + O_2$$
$$Fe_2O_3 + 3C \rightarrow 2Fe + 3CO$$

(C) According to electronic transition, any atom, molecule or ion is said to be reduced when accepts electrons.

$$F + e^- \rightarrow F^-$$
$$Cl + e^- \rightarrow Cl^-$$
$$S + 2e^- \rightarrow S^{2-}$$
$$Sn^{4+} + 2e^- \rightarrow Sn^{2+}$$
$$Fe^{3+} + e^- \rightarrow Fe^{2+}$$

(D) Decrease in oxidation number of any species is called the reduction of that species. The decrease in oxidation number is tendency of gaining electrons.

Concept of Oxidation Number :

The oxidation is always accompanied by an equivalent amount of reduction. Therefore, the reactions which involve oxidation and reduction simultaneously are known as **redox reactions.** The redox reactions involve transference of electrons from one species to another. The transference of electrons can be easily understood in case of ionic species because the charge on them also changes during redox changes. However, the redox changes in case of covalent compounds cannot be easily explained in terms of transference of electrons. For example, in a chemical change between zinc and copper ions

$$Zn_{(s)} + Cu^{2+}_{(aq)} \rightarrow Zn^{2+}_{(aq)} + Cu_{(s)}$$

it is quite evident that zinc loses electrons and Cu^{2+} gains the electrons. But in a chemical change between H_2 and Cl_2

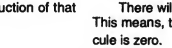
$$H_{2(g)} + Cl_{2(g)} \rightarrow 2HCl_{(g)}$$

the loss and gain of electrons is not easily understood. Thus in order to explain transference of electrons in either of the species in a more convenient way, the concept of **oxidation number** has been introduced.

Oxidation Number (O.N.) of an element is defined as the residual charge which its atom has or appears to have when all other atoms from the molecule are removed as ions.

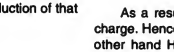
During the removal of atoms, the electrons are counted according to the following two fundamental rules :

(1) Electrons shared between two similar atoms are divided equally between sharing atoms. For example, in chlorine molecule as—



There will be no net charge on each atom of chlorine. This means, the oxidation number of chlorine in Cl_2 molecule is zero.

(2) Electrons shared between two dissimilar atoms are counted with the more **electronegative** atom. For example, as in HCl molecule—



As a result of this chlorine acquires a unit negative charge. Hence oxidation number of Cl atom is – 1. On the other hand H atom is without electron will have a unit positive charge. Hence oxidation number of H atom is + 1.

Thus atoms can have positive, zero or negative values of oxidation number depending upon their mode of combination in a molecule. Actually the oxidation number is the charge assigned to the atom in a species according to some arbitrary rules as described below—

Rules for Assigning Oxidation Number of an Atom :

- The oxidation number of an atom is zero in a neutral substance that contains atoms of only one element. Thus,
  Oxidation number of inert gases (He) = 0
  Oxidation number of chlorine in Cl_2 = 0
  Oxidation number of sulphur in S_8 = 0
  Oxidation number of phosphorus in P_4 = 0
- The oxidation number of monoatomic ions is equal to the charge on the ion. The oxidation number of sodium ion is + 1 and that of chlorine is – 1 in NaCl molecule.
- The oxidation number of hydrogen is + 1 when it is combined with a non-metal. Oxidation number of hydrogen is + 1 in CH_4, NH_3, H_2O and HCl.
- Oxidation number of hydrogen is – 1 when it is combined with metals. Hydrogen is, therefore, in – 1 oxidation number in LiH, NaH, CaH_2 and $LiAlH_4$.
- Oxidation number of fluorine is always – 1 in all its compounds.
- Oxygen is assigned oxidation number of – 2 in most of its compounds, however, in peroxides like H_2O_2, BaO_2. Na_2O_2 etc., its oxidation number – 1. Similarly, the exception also occurs in compounds of fluorine and oxygen like OF_2 and O_2F_2 in which the oxidation number of oxygen is + 2 and + 1 respectively.
- The algebraic sum of the oxidation numbers of all the atoms in a neutral molecule is zero. But in case of

complex ion the sum of oxidation numbers of all its atoms is equal to the charge on the ion.

Example (A)—To determine oxidation number of each element in following compounds—

(A) BaO_2 (B) $(NH_4)_2\,MoO_4$

(C) $Na_3Co(NO_2)_6$ (D) CS_2

(A) If the oxidation number of oxygen in BaO_2 is – 2, the oxidation number of Ba will be + 4. But Ba always has oxidation number of + 2. Thus this compound must be $[Ba^{2+}]\,[O_2^{2-}]$. Barium is + 2 and oxygen is – 1.

(B) $(NH_4)_2\,MoO_4$ contains NH_4^+ ions in which hydrogen is in + 1 state and nitrogen in – 3. Because there are two NH_4^+ ions, the other half of the compound must be MoO_4^{2-} ion in which Mo is in + 6 and oxygen is in – 2.

(C) Sodium is in + 1 oxidation state in all its compounds. This compound, therefore, contains the $[Co(NO_2)_6]^{3-}$ ion. This complex ion contains six NO_2^- ions in which oxidation number of nitrogen is + 3 and oxygen is – 2. The oxidation state of the cobalt atom is, therefore, + 3.

(D) The most electronegative element in a compound always has a negative oxidation state. Since S tends to form – 2 ions, the oxidation number of S in CS_2 is – 2 and that of carbon is + 4.

Example (B)—To calculate oxidation number of underlined elements in the following species—

(A) $\underline{Cr}_2O_7^{2-}$ (B) $\underline{C}H_2Cl_2$

(C) $\underline{P}O_4^{3-}$ (D) $K_2\underline{Mn}O_4$

(E) $\underline{N}H_4^+$

(A) Oxidation number of Cr in $Cr_2O_7^{2-}$:

Let O.N. of Cr be x

O.N. of each O atom $= -2$

Sum of O.N. of all atoms $= 2x + 7(-2)$

$= 2x - 14$

Sum of O.N. must be equal to the charge on the ion

$\therefore \quad 2x - 14 = -2$

$$x = \frac{-2+14}{2}$$

$x = +6$

(B) Oxidation number of C in CH_2Cl_2 :

Let O.N. of C $= x$

O.N. of each H atom $= +1$

O.N. of each Cl atom $= -1$

Sum of O.N. must be equal to zero.

$\therefore \quad x + 2(+1) + 2(-1) = 0$

or, $x + 2 - 2 = 0$

Sum of O.N. must be zero, hence

$\therefore \quad x = 0$

Hence O.N. of C is zero.

(C) Oxidation number of P in PO_4^{3-} :

Let O.N. of P $= x$

O.N. of each O atom $= -2$

Sum of O.N. of all atoms $= x + 4(-2) = x - 8$

The sum must be equal to the total charge *i.e.*, – 3.

$x - 8 = -3$

$x = -3 + 8$

$x = +5$

(D) Oxidation number of Mn in K_2MnO_4 :

Let O.N. of Mn $= x$

O.N. of each O atom $= -2$

O.N. of each of K atom $= +1$

Sum of O.N. of all atoms $= 2(+1) + x + 4(-2)$

$= 2 + x - 8$

$= x - 6$

Sum must be equal to zero

$x - 6 = 0$

$x = +6$

(E) Oxidation number of N in NH_4^+ ion :

Let O.N. of N $= x$

O.N. of each H atom $= +1$

Sum of O.N. of all atoms $= x + 4(+1) = x + 4$

$x + 4 = +1$

$x = -3$

Example (C)—The oxidation number of any element can never be in fraction. If oxidation number of any element is in fraction, it is **resultant oxidation** number of that element—

To determine oxidation number of underlined elements in the following compounds—

(A) $\underline{Fe}_3O_4$ (B) $Na_2\underline{S}_2O_3$

(C) $Na_2\underline{S}_4O_6$ (D) $\underline{N}_3H$

(A) Oxidation number of Fe in Fe_3O_4.

Let the oxidation number of Fe $= x$

O.N. of each O atom $= -2$

Sum of O.N. of all atoms $= 3x + 4(-2) = 3x - 8$

Sum of O.N. must be zero

Hence, $3x - 8 = 0$

$$x = \frac{8}{3}, = +2\frac{2}{3} \text{ or } +2{\cdot}6$$

We know that Fe_3O_4 is a mixed oxide ($FeO + Fe_2O_3$)

In FeO, the O.N. of Fe is + 2 and in Fe_2O_3 it is + 3.

Hence resultant O.N. $= \frac{2+3+3}{3} = +\frac{8}{3}$

Note : The Pb_3O_4 is also a mixed oxide ($2\,PbO + PbO_2$). In PbO, the O.N. of Pb is + 2 and PbO_2 it is + 4.

Hence resultant O.N. $= \frac{2+2+4}{3} = \frac{8}{3}$

(B) Oxidation number of S in $Na_2S_2O_3$.

Let the O.N. of S $= x$

O.N. of all Na atoms $= +1$

O.N. of all O atoms $= -2$

Sum of O.N. of all atoms $= 2(+1) + 2x + 3(-2)$

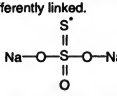
$= 2x - 4$

Sum of all O.N. must be zero.

Hence $2x - 4 = 0$

$$x = \frac{4}{2} = +2$$

When we write structural formula of $Na_2S_2O_3$ molecule, S atoms are differently linked.



The oxidation state of central S atom is + 6 and that of S^* atom is – 2.

Hence resultant O.N. $= \frac{4 + 0}{2} = +2$

(C) Oxidation number of S in $Na_2S_4O_6$.

Let O.N. of S $= x$

O.N. of all Na atoms $= +1$

O.N. of all O atoms $= -2$

Sum of all O.N. $= 2(+1) + 4x + 6(-2)$

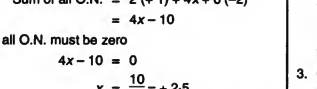
$= 4x - 10$

Sum of all O.N. must be zero

Hence $4x - 10 = 0$

$x = \frac{10}{4} = +2.5$

When we write the structural formula of $Na_2S_4O_6$ molecules S atoms are differently linked.



Two S atoms namely S^2 and S^3 are joined together and with two other S atoms S^1 and S^4, therefore, their oxidation state will be zero. S atoms namely S^1 and S^4 have oxidation number + 5 each.

Hence resultant oxidation number of sulphur in $Na_2S_4O_6$ will be

$\frac{0 + 0 + 5 + 5}{4} = +2.5$

(D) Oxidation number of N in N_3H :

Let the oxidation number of N atom

$= x$

O.N. of hydrogen atom $= +1$

Sum of O.N. of all atoms

$= 3x + 1$

Sum of oxidation numbers must be equal to zero

Hence $3x + 1 = 0$

$x = -\frac{1}{3}$

When we write structural formula of N_3H, then we find that N atoms are differently linked.

The oxidation number of N^1 and N^2 is zero and that of N^3 is –1.

Thus resultant O.N. of N $= \frac{0 + 0 + (-1)}{3} = -\frac{1}{3}$

Difference Between Oxidation Number and Valency

Oxidation Number	Valency
1. Oxidation number is residual charge which an atom has or appears to have when other atoms from the molecule are removed as ions by counting the shared electrons with more electronegative atoms.	1. Valency is the combining capacity or power of an element. It is expressed as number of H atoms which combine with one atom of the element.
2. Oxidation number refers to the charge. It can be + ve, zero or – ve. For example, in CCl_4, the oxidation number of C is + 4 and that of Cl is – 1.	2. Valency is a number only and does not refers to any charge. For example, in CCl_4, the valency of carbon is 4 and that of chlorine is 1.
3. Oxidation number of an element is in whole number. However, the resultant oxidation number of an element in a compound may have fractional value. For example, in $Na_2S_4O_6$, two S atoms are in O oxidation state while two S atoms are in + 5 oxidation states. The resultant O.N. $\frac{0 + 0 + 5 + 5}{4} = 2.5$	3. Valency of an element is always in whole number. It can never be in fraction number.
4. Elements like C, N, O have constant valency can have variable oxidation numbers. For example valency of carbon is 4 but it O.N. can vary from – 4 to + 4 as below : $\overset{-4}{CH_4}$, $\overset{-2}{CH_3Cl}$, $\overset{0}{CH_2Cl_2}$, $\overset{+2}{CHCl_3}$, $\overset{+4}{CCl_4}$	4. Most of the elements of representative groups show constant valency.

Redox Reactions :

Since oxidation involves loss of electrons and reduction involves the gain of electrons it is evident that if one substance loses the electrons, another substance at the same time must gain electrons because the electrons cannot be the products of any chemical change. This means that in any chemical process, oxidation can occur only if reduction is also taking place side by side and vice versa. This is the reason that reactions involving oxidation and reduction are called **redox reactions.** During redox reaction there is transference of electrons from the **reducing agent** to the **oxidising agent.**

$$\underset{\text{Oxidising agent (A)}}{\downarrow} \xrightarrow{e^-} \underset{\text{Reducing agent (B)}}{|} \rightarrow \underset{\text{Reduced product}}{A^-} + \underset{\text{Oxidised product}}{B^+}$$

Oxidation : Loss of electrons

Reduction : Gain of electrons

Oxidising agent : Species which gains electrons and itself is reduced

Reducing agent : Species which loses electrons and itself is oxidised.

Points to Remember

- Highest oxidation number of an element is equal to its group number in periodic table. For example : Halogens (except F) have highest oxidation number of + 7.
  e.g., Cl_2O_7, IF_7 etc.
  Sulphur has upto + 6.
  Nitrogen and phosphorus have upto + 5.
- Highest negative oxidation number of an element is given by 8-group number.
  For halogens, 8 – 7 = 1; hence upto – 1
  For oxygen and sulphur, 8 – 6 = 2; hence upto – 2
  For nitrogen and phosphorus, 8 – 5 = 3; hence upto – 3.
- Strength of oxyacids formed by an element is directly proportional to the oxidation number of the element. For example :
  $\overset{+1}{H\underline{Cl}O} < \overset{+3}{H\underline{Cl}O_2} < \overset{+5}{H\underline{Cl}O_3} < \overset{+7}{H\underline{Cl}O_4}$
  $\overset{-2}{H_2\underline{S}} < \overset{+4}{H_2\underline{S}O_3} < \overset{+6}{H_2\underline{S}O_4}$
  $\overset{+3}{H\underline{N}O_2} < \overset{+5}{H\underline{N}O_3}$
- Strength of alkalies is inversely proportional to the oxidation number of cation.
  $\overset{+1}{\underline{Na}OH} > \overset{+2}{\underline{Ca}(OH)_2} > \overset{+3}{\underline{Al}(OH)_3}$
- General oxidation number of oxygen is – 2. However, it has –1 state in peroxides (—O—O—), $-\frac{1}{2}$ in superoxides (O_2^-), + 2 in oxygen difluoride (OF_2) and + 1 in dioxygen difluoride (O_2F_2).

Redox-Reactions in daily life—We find examples of redox reactions almost every time we analyse the reactions used as a source of either heat or work. When **natural gas** burns, a redox reaction occurs that releases more than 800 kJ/mol of energy.

$$CH_{4(g)} + 2O_{2(g)} \longrightarrow CO_{2(g)} + 2H_2O_{(g)}$$

Within our body, a sequence of redox reactions burns sugars, such as glucose ($C_6H_{12}O_6$) and the fatty acids in the fat we eat—

$$C_6H_{12}O_{6(aq)} + 6O_{2(g)} \longrightarrow 6\ CO_{2(g)} + 6H_2O_{(l)}$$

$$CH_3(CH_2)_{16}CO_2H_{(aq)} + 26O_{2(g)} \longrightarrow 18\ CO_{2(g)} + 18H_2O_{(l)}$$

We do not have to restrict ourselves to reactions that can be used as a source of energy, however, to find example of redox reactions. Silver metal, is oxidised when it comes in contact with a trace quantity of H_2S or SO_2 in the atmosphere, or food, such as eggs, that are rich in sulphur compounds.

$$4\ Ag_{(s)} + 2H_2S_{(g)} + O_{2(g)} \longrightarrow 2\ Ag_2S_{(s)} + 2H_2O_{(g)}$$

The tarnishing of silver is just one example of a broad class of oxidation-reduction reactions that fall under general heading of **corrosion.**

Another example is the series of reactions that occurs when iron or steel rusts. When heated, iron reacts with oxygen to form a mixture of iron (II) and iron (III) oxides—

$$2\ Fe_{(s)} + O_{2(g)} \longrightarrow 2\ FeO_{(s)}$$

$$4\ Fe_{(s)} + 3O_2 \longrightarrow 2\ Fe_2O_{3(s)}$$

Molten iron even reacts with water to form aqueous solution of Fe^{2+} ions and H_2 gas—

$$Fe_{(l)} + 2\ H_2O_{(l)} \longrightarrow Fe^{2+}_{(aq)} + 2OH^-_{(aq)} + H_{2(g)}$$

At room temperature all above three reactions are so slow, they can be ignored.

Iron only corrodes at room temperature in presence of oxygen and water. In the course of this reaction, the iron is oxidised to give a hydrated form of Fe (II) oxide.

$$2\ Fe_{(s)} + O_{2(aq)} + H_2O_{(l)} \longrightarrow 2\ FeO.H_2O_{(s)}$$

As the compound $FeO.H_2O$ has same empirical formula as $Fe(OH)_2$, it is often mistakenly called iron (II) or ferrous hydroxide. The $FeO.H_2O$ formed in this reaction is further oxidised by O_2 dissolved in water to give hydrated form of iron (III) or ferric oxide—

$$4\ FeO.H_2O_{(s)} + O_{2(aq)} + 2\ H_2O_{(l)} \longrightarrow 2\ Fe_2O_3.3\ H_2O_{(s)}$$

$FeO.H_2O$ formed at the surface of metal combines with $Fe_2O_3.3H_2O$ to give a hydrated form of **magnetic iron oxide (Fe_3O_4)**—

$$FeO.H_2O_{(s)} + Fe_2O_3.3\ H_2O_{(s)} \longrightarrow Fe_3O_4.nH_2O_{(s)}$$

Recognizing Redox Reactions—Chemical reactions are often divided into two categories **redox-reactions** and **metathesis reactions.** Metathesis reactions involve acid-base reactions that involve the transfer of H^+ ions from **Bronsted acid** to **Bronsted base.**

$$\underset{\text{Bronsted acid}}{CH_3CO_2H_{(aq)}} + \underset{\text{Bronsted base}}{OH^-_{(aq)}} \rightleftharpoons \underset{\text{Bronsted base}}{CH_3CO^-_{2(aq)}} + \underset{\text{Bronsted acid}}{H_2O_{(l)}}$$

Metathesis reactions also involve sharing of pair of electrons by an electron pair donor (Lewis base) and an electron pair acceptor (Lewis acid)—

$$\underset{\text{Lewis acid}}{Co^{3+}_{(aq)}} + \underset{\text{Lewis base}}{6\ NO^-_{2(aq)}} \rightleftharpoons [Co(NO_2)_6]^{3-}_{(aq)}$$

Redox reactions involve the transfer of one or more electrons—

$$Cu_{(s)} + 2\ Ag^+_{(aq)} \longrightarrow Cu^{2+}_{(aq)} + 2\ Ag_{(s)}$$

They can also occur by the transfer of oxygen, hydrogen or halogen atoms—

$$CO_{2(g)} + H_{2(g)} \longrightarrow CO_{(g)} + H_2O_{(g)}$$

$$SF_{4(g)} + F_{2(g)} \longrightarrow SF_{6(g)}$$

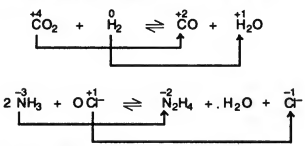
Fortunately, there is an almost fool proof method of distinguishing between **metathesis** and **redox reactions.** Reactions in which none of the atoms undergoes a change in oxidation number, are called **metathesis** reactions.

Following are examples of **metathesis reactions**—

$$\overset{+3}{P}\overset{-1}{Cl_3} + 3\overset{+1}{H_2}\overset{-2}{O} \rightleftharpoons \overset{+1}{H_3}\overset{+3}{P}\overset{-2}{O_3} + 3\overset{+1}{H}\overset{-1}{Cl}$$

$$\overset{+3}{Co}^{3+} + 6\overset{+3}{N}\overset{-2}{O_2^-} \rightleftharpoons [\overset{+3}{Co}(\overset{+3}{N}\overset{-2}{O_2})_6]^{3-}$$

Following are examples of **redox reactions**—



Balancing Redox-Reaction Equations :

Goals of Balancing chemical equation—

(1) The same number of atoms of each element is found on both sides of the equation and, therefore, mass is conserved.

(2) The sum of +ve charge and –ve charge is the same on both the sides of the equation and, therefore, charge is conserved, because electrons are neither created nor destroyed in a chemical reaction—

Half-Reaction Method of Balancing Redox-Equation :

The powerful technique for balancing redox reaction equations involves dividing these reactions into separate oxidation and reduction half-reactions. We then balance the half-reactions, one at a time, and combine them so that electrons are neither created nor destroyed in the reaction.

The steps involved in half-reaction method for balancing equations can be illustrated by considering the reaction used to determine the amount of tri-iodide ion (I_3^-) in a solution by titration.

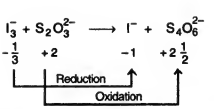
Step–1 : Write a skeleton equation for the reaction. The skeleton equation for the reaction on which this titration is based, can be written as follows—

$$I_3^- + S_2O_3^{2-} \longrightarrow I^- + S_4O_6^{2-}$$

Step–2 : Assign oxidation numbers to atoms on both the sides of equation. The negative charge on the I_3^- is formally distributed over three iodine atoms, which means that the average oxidation state of the iodine atoms in this ion is $-\frac{1}{3}$. In the $S_4O_6^{2-}$ ion, the total oxidation state of S atoms is + 10. The average oxidation state of S atoms is, therefore, $2\frac{1}{2}$.

$$\underset{-\frac{1}{3}}{I_3^-} + \underset{+2}{S_2O_3^{2-}} \longrightarrow \underset{-1}{I^-} + \underset{+2\frac{1}{2}}{S_4O_6^{2-}}$$

Step–3 : Determine which atoms are oxidised and which are reduced.



Step–4 : Divide the reaction into oxidation and reduction half-reactions and balance these reactions, one at a time.

Oxidation— $S_2O_3^{2-} \longrightarrow S_4O_6^{2-}$

$+2 \qquad +2\frac{1}{2}$

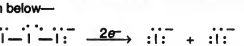
Reduction— $I_3^- \longrightarrow I^-$

$-\frac{1}{3} \qquad -1$

Our goal is to balance half-reaction in terms of both charge and mass. It seems reasonable to start by balancing number of atoms on both sides of a half-reaction.

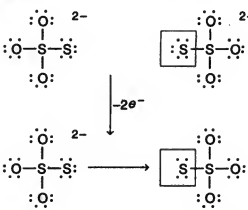
Reduction— $I_3^- \longrightarrow 3I^-$

We then balance the charge by noting that two electrons must be added to an I_3^- ion to produce $3I^-$ ions as can be seen from the Lewis Structures of these ions shown below—



Reduction— $I_3^- + 2e^- \longrightarrow 3I^-$

We now turn to oxidation half-reaction, the Lewis Structures of $S_2O_3^{2-}$ and $S_4O_6^{2-}$ suggest that we can get an $S_4O_6^{2-}$ ion by removing two electrons from a pair of $S_2O_3^{2-}$ ions.



Step–5 : Combine these half-reactions, so that electrons are neither created nor destroyed.

$$(2\,S_2O_3^{2-} \longrightarrow S_4O_6^{2-} + 2e^-)$$
$$+ (I_3^- + 2e^- \longrightarrow 3I^-)$$
$$\overline{I_3^- + 2S_2O_3^{2-} \longrightarrow 3I^- + S_4O_6^{2-}}$$

Step–6 : Balance the remainder of equation by inspection, if necessary. Since, overall reaction is already balanced in terms of mass and charge, we simply introduce the symbols describing the states of the reactants and products—

$$I_{3(aq)}^- + 2S_2O_3^{2-}{}_{(aq)} \longrightarrow 3I_{(aq)}^- + S_4O_6^{2-}{}_{(aq)}$$

Redox-Reactions in Acidic Solutions :

Step–1 : Skeleton equation for the reaction

$$SO_2 + Cr_2O_7^{2-} \xrightarrow{H^+} SO_4^{2-} + Cr^{3+}$$

Step–2 : Assign oxidation numbers to atoms on both the sides of the equation.

$$\underset{+4}{S}O_2 + \underset{+6}{Cr_2}O_7^{2-} \longrightarrow \underset{+6}{S}O_4^{2-} + \underset{+3}{Cr^{3+}}$$

Step–3 : Determine which atoms are oxidised and which are reduced.

$$\underset{+4}{S}O_2 + \underset{+6}{Cr_2}O_7^{2-} \longrightarrow \underset{+6}{S}O_4^{2-} + \underset{+3}{Cr^{3+}}$$

Oxidised (S: +4 → +6)

Reduced (Cr: +6 → +3)

Step–4 : Divide the reaction into oxidation half and reduction half-reactions

Oxidation— $\underset{+4}{SO_2} \longrightarrow \underset{+6}{SO_4^{2-}}$

Reduction— $\underset{+6}{Cr_2O_7^{2-}} \longrightarrow \underset{+3}{Cr^{3+}}$

Balancing the charge and mass in both the half-reactions—

Reduction— $Cr_2O_7^{2-} + \boxed{6e^-} \longrightarrow 2\,Cr^{3+}$

$$Cr_2O_7^{2-} + 6e^- \longrightarrow 2Cr^{3+} + \boxed{7O^{2-}}$$

Note—It does not make sense to unite this half-reaction in the above form. The reaction is in acidic medium, O^{2-} ion is a very strong base that would immediately combine with H^+ ions to give water.

Following is more realistic equation for this half-reaction

$$Cr_2O_7^{2-} + \boxed{14H^+} + 6e^- \longrightarrow 2Cr^{3+} + \boxed{7H_2O}$$

Oxidation :

Balancing the charge and mass in both sides of oxidation half-reaction

$$SO_2 \longrightarrow SO_4^{2-} + \boxed{2e^-}$$

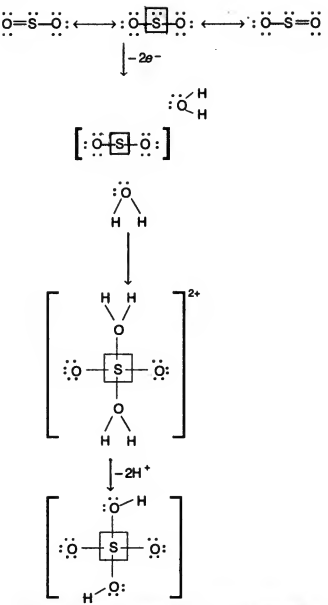
The key to balancing the charge on both sides of the equation is remembering that the reaction is run in acid, which contains both H^+ and H_2O. We can, therefore, add H^+ ions or H_2O to either side of the equation, as needed. The only way to baiance charge on both the sides of this equation is to add H^+ ions to the product side

$$SO_2 \longrightarrow SO_4^{2-} + \boxed{4H^+} + 2e^-$$

We can then balance the number of hydrogen and oxygen atoms on both the sides of this equation by adding a pair of H_2O molecules to the reactants side.

$$SO_2 + \boxed{2H_2O} \longrightarrow SO_4^{2-} + 4H^+ + 2e^-$$

This equation can be understood in terms of Lewis structures shown below—



Thus, two electron oxidation of SO_2 in presence of H_2O leads to the formation of a SO_4^{2-} ion and four H^+ ions.

Step–5 : Combine two half-reactions so that electrons are neither created nor destroyed.

$$(Cr_2O_7^{2-} + 14H^+ + 6e \longrightarrow 2Cr^{3+} + 7H_2O)$$
$$+3(SO_2 + 2H_2O \longrightarrow SO_4^{2-} + 2e^- + 4H^+)$$

$$Cr_2O_7^{2-} + 3\,SO_2 + 14H^+ + 6H_2O \longrightarrow 2\,Cr^{3+} + 3SO_4^{2-} + 12H^+ + 7H_2O$$

Step–6 : Balance the remainder of the equation by inspection, if necessary—Although the equation appears balanced, we are not quite finished with it. We can simplify the equation by subtracting $12H^+$ ions and $6H_2O$ molecules from each side to generate the following balanced equation.

$$Cr_2O_{7\,(aq)}^{2-} + 3SO_{2(aq)} + 2H_{(aq)}^+ \longrightarrow 2\,Cr_{(aq)}^{3+} + 3SO_{4(aq)}^{2-} + H_2O_{(l)}$$

Redox Reactions in Basic Solutions :

Step–1 : Skeleton equation

$$MnO_4^- + H_2O_2 \xrightarrow{OH^-} MnO_2 + O_2$$

Step–2 : Assign oxidation numbers to atoms on both the sides

$$\underset{+7\ -2}{MnO_4^-} + H_2O_2 \longrightarrow \underset{+4\ -2}{MnO_2} + \underset{0}{O_2}$$
$$+1\ -1$$

Step–3 : Determine which atoms are oxidised and which are reduced

$$\underset{+7}{MnO_4^-} + H_2O_2 \longrightarrow \underset{+4}{MnO_2} + \underset{0}{O_2}$$
$$-1$$

Reduced

Oxidised

Step–4 : Divide the reaction into oxidation half and reduction half-reaction and balance these half-reactions

Reduction— $\underset{+7}{MnO_4^-} \longrightarrow \underset{+4}{MnO_2}$

Oxidation— $\underset{-1}{H_2O_2} \longrightarrow \underset{0}{O_2}$

Let us start by balancing the reduction half reaction. It takes three electrons to reduce Mn from the +7 to +4 oxidation state.

Reduction— $MnO_4^- + \boxed{3e^-} \longrightarrow MnO_2$

We now try to balance either the number of atoms or the charge on the both sides of the equation. Since the reaction is run in basic solution, we can add either OH^- ions or H_2O molecules to either side of the equation, as needed. The key to deciding which side of the equation gets each of these reagents is simple. The only way to balance the net charge of –4 on left side of equation is to add four OH^- ions to the products

Reduction— $MnO_4^- + 3e^- \longrightarrow MnO_2 + \boxed{4OH^-}$

We can then balance the number of hydrogen and oxygen atoms by adding two H_2O molecules to the reactants.

Reduction— $MnO_4^- + 3e^- + \boxed{2H_2O} \longrightarrow MnO_2 + 4OH^-$

We now turn to oxidation half reaction. Two electrons are lost when H_2O_2 is oxidised to form O_2 molecule.

Oxidation— $H_2O_2 \longrightarrow O_2 + \boxed{2e^-}$

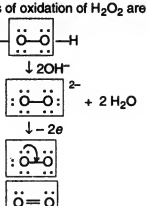
We can balance the charge by adding a pair of OH^- ions to the reactants.

Oxidation— $H_2O_2 + \boxed{2OH^-} \longrightarrow O_2 + 2e^-$

The only way to balance H and O atoms is to add H_2O molecules to the products.

Oxidation— $H_2O_2 + 2OH^- \longrightarrow O_2 + \boxed{2H_2O} + 2e^-$

Lewis structures of oxidation of H_2O_2 are shown as—



Step–5 : Combine two half-reactions so that electrons are neither created nor destroyed

$$2(MnO_4^- + 3e^- + 2H_2O \longrightarrow MnO_2 + 4OH^-)$$
$$+ 3(H_2O_2 + 2OH^- \longrightarrow O_2 + 2H_2O + 2e^-)$$

$$2MnO_4^- + 3H_2O_2 + 6OH^- + 4H_2O \longrightarrow 2MnO_2 + 3O_2 + 8OH^- + 6H_2O$$

Step–6 : Balance the remainder of the equation by inspection, if necessary

$$2MnO_{4(aq)}^- + 3H_2O_{2(aq)} \longrightarrow 2MnO_{2(s)} + 3O_{2(g)} + 2OH_{(aq)}^- + 2H_2O_{(l)}$$

Molecular Redox Reactions :

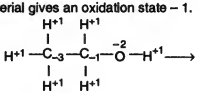
Lewis structures can play a vital role in understanding oxidation–reduction reactions with complex molecules. Consider the following reaction, for example, which is used in the **Breathalyser** to determine the amount of ethyl alcohol or ethanol on the breath of individuals who are suspected of driving while under the influence—

$$3CH_3CH_2OH_{(g)} + 2Cr_2O_7^{2-}{}_{(aq)} + 16H_{(aq)}^+ \longrightarrow 3CH_3CO_2H_{(aq)} + 4Cr_{(aq)}^{3+} + 11H_2O_{(l)}$$

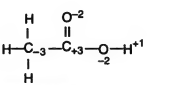
We can balance the oxidation half reaction in terms of the molecular formulas of the starting material and the product of this half reaction :

Oxidation— $C_2H_6O \longrightarrow C_2H_4O_2$

Now we assign oxidation number to each of the carbon atoms in the Lewis structures of the components of this reaction. The C atom in CH_3—group in ethanol is assigned oxidation number – 3 so that it can balance oxidation states of three substituents it carries. Applying the same technique to the —CH_2OH group in the starting material gives an oxidation state – 1.



Ethanol



Acetic acid

One C atom in acetic acid has same oxidation number as it had in ethanol *i.e.*, – 3. There is a change in the oxidation number of the other C atom, however, from – 1 to + 3. The oxidation half reaction, therefore, formally corresponds to the loss of four electrons by one of the C atoms.

Oxidation— $CH_3CH_2OH \longrightarrow CH_3COOH + \boxed{4e^-}$

As this reaction is run in acidic medium, we can add H^+ or H_2O as needed to balance the equation.

Oxidation— $CH_3CH_2OH + \boxed{H_2O} \longrightarrow CH_3COOH + 4e^- + \boxed{4H^+}$

The other half reaction involves a six electron reduction of the $Cr_2O_7^{2-}$ ion in acidic solution to form a pair of Cr^{3+} ions.

Reduction— $Cr_2O_7^{2-} + \boxed{6e^-} \longrightarrow 2Cr^{3+}$

Adding H^+ ions and H_2O molecules as needed gives the following balanced equation for this half reaction.

Reduction— $Cr_2O_7^{2-} + \boxed{14H^+} + 6e^- \longrightarrow 2Cr^{3+} + \boxed{7H_2O}$

We are now ready to combine the two half reactions by assuming that electrons are neither created nor destroyed in this reaction.

$$3(CH_3CH_2OH + H_2O \longrightarrow CH_3COOH + 4e^- + 4H^+)$$
$$2(Cr_2O_7^{2-} + 14H^+ + 6e^- \longrightarrow 2Cr^{3+} + 7H_2O)$$

$$3CH_3CH_2OH + 2Cr_2O_7^{2-} + 28H^+ + 3H_2O \longrightarrow 3CH_3COOH + 4Cr^{3+} + 12H^+ + 14H_2O$$

Simplifying this equation by removing $3H_2O$ and $12H^+$ from both sides of the equation gives the balanced equation for this reaction.

$$3CH_3CH_2OH_{(g)} + 2Cr_2O_{7(aq)}^{2-} + 16H_{(aq)}^+ \longrightarrow 3CH_3COOH_{(aq)} + 4\,Cr_{(aq)}^{3+} + 11H_2O_{(l)}$$

Common Oxidising and Reducing Agents :

- Atoms, ions and molecules that have an unusually **large affinity** for electrons tend to be good **oxidising agents**. Elemental fluorine, for example, is a strongest oxidising agent. F_2 is such a good oxidising agent that metals, quartz, asbestos and even water burst in to flame in its presence. Other good oxidising agents include O_2, O_3 and Cl_2 which are the elemental forms of second and third most electronegative elements, respectively.
- Another place to look for good oxidising agents is among compounds with unusually large oxidation states, such as MnO_4^-, CrO_4^{2-}, $Cr_2O_7^{2-}$ as well as HNO_3, $HClO_4$ and H_2SO_4. These compounds are strong oxidising agents because elements become more electronegative as the oxidation state of their atoms increase.
- Good reducing agents include the active metals such as Na, Mg, Al and Zn, which have relatively small **Ionization energy** and low **electronegativity**. Metal hydrides, such as NaH, CaH_2 and $LiAlH_4$, which formally contains H^- ions are also good reducing agents.
- Some compounds can act either oxidising or reducing agents. One example is hydrogen gas, which acts as an oxidising agent when it combines with metals and as a reducing agent when it reacts with non-metals. Another example is hydrogen peroxide, in which oxygen atom is in – 1 state. Since this oxidation state lies between the extremes of the more common 0 and – 2 oxidation states of oxygen H_2O_2 can act either as an oxidising agent or a reducing agent.

The Relative Strengths of Common Oxidizing Agents and Reducing Agents

	$K^+ + e^- \rightleftharpoons K$	Best reducing agents
	$Ba^{2+} + 2e^- \rightleftharpoons Ba$	
	$Ca^{2+} + 2e^- \rightleftharpoons Ca$	
	$Na^+ + e^- \rightleftharpoons Na$	
	$Mg^{2+} + 2e^- \rightleftharpoons Mg$	
	$H_2 + 2e^- \rightleftharpoons 2H^-$	
	$Al^{3+} + 3e^- \rightleftharpoons Al$	
	$Mn^{2+} + 2e^- \rightleftharpoons Mn$	
	$Zn^{2+} + 2e^- \rightleftharpoons Zn$	
	$Cr^{3+} + 3e^- \rightleftharpoons Cr$	
	$S + 2e^- \rightleftharpoons S^{2-}$	
	$2CO_2 + 2H^+ + 2e^- \rightleftharpoons H_2C_2O_4$	
	$Cr^{3+} e^- \rightleftharpoons Cr^{2+}$	
	$Fe^{2+} + 2e^- \rightleftharpoons Fe$	
	$Co^{2+} + 2e^- \rightleftharpoons Co$	
	$Ni^{2+} + 2e^- \rightleftharpoons Ni$	
	$Sn^{2+} + 2e^- \rightleftharpoons Sn$	
	$Pb^{2+} + 2e^- \rightleftharpoons Pb$	
	$Fe^{3+} + 3e^- \rightleftharpoons Fe$	
	$2H^+ + 2e^- \rightleftharpoons H_2$	
	$S_4O_6^{2-} + 2e^- \rightleftharpoons 2\,S_2O_3^{2-}$	
	$Sn^{4+} + 2e^- \rightleftharpoons Sn^{2+}$	
	$Cu^{2+} + e^- \rightleftharpoons Cu^+$	
	$O_2 + 2H_2O + 4e^- \rightleftharpoons 4\,OH^-$	
	$Cu^+ + e^- \rightleftharpoons Cu$	
	$I_2 + 2e^- \rightleftharpoons 2I^-$	
Oxidizing power increases ↓	$MnO_4^- + 2H_2O + 3e^- \rightleftharpoons MnO_2 + 4\,OH^-$	↑ Reducing power increases
	$O_2 + 2H^+ + 2e^- \rightleftharpoons H_2O_2$	
	$Fe^{3+} + e^- \rightleftharpoons Fe^{2+}$	
	$Hg_2^{2+} + 2e^- \rightleftharpoons 2\,Hg$	
	$Ag^+ + e^- \rightleftharpoons Ag$	
	$Hg^{2+} + 2e^- \rightleftharpoons Hg$	
	$H_2O_2 + 2e^- \rightleftharpoons 2\,OH^-$	
	$HNO_3 + 3H^+ + 3e^- \rightleftharpoons NO + 2H_2O$	
	$Br_2 + 2e^- \rightleftharpoons 2\,Br^-$	
	$2IO_3^- + 12H^+ + 10e^- \rightleftharpoons I_2 + 6H_2O$	
	$CrO_4^{2-} + 8H^+ + 3e^- \rightleftharpoons Cr^{3+} + 4H_2O$	
	$Pt^{2+} + 2e^- \rightleftharpoons Pt$	
	$MnO_2 + 4H^+ + 2e^- \rightleftharpoons Mn^{2+} + 2H_2O$	
	$O_2 + 4H^+ + 4e^- \rightleftharpoons 2H_2O$	
	$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightleftharpoons 2Cr^{3+} + 7H_2O$	
	$Cl_2 + 2e^- \rightleftharpoons 2\,Cl^-$	
	$PbO_2 + 4H^+ + 2e^- \rightleftharpoons Pb^{2+} + 2H_2O$	
	$MnO_4^- + 8H^+ + 5e^- \rightleftharpoons Mn^{2+} + 4H_2O$	
	$Au^+ + e^- \rightleftharpoons Au$	
	$H_2O_2 + 2H^+ + 2e^- \rightleftharpoons 2H_2O$	
	$Co^{3+} + e^- \rightleftharpoons Co^{2+}$	
Best oxidizing agents	$S_2O_8^{2-} + 2e^- \rightleftharpoons 2\,SO_4^{2-}$	
	$O_3 + 2H^+ + 2e^- \rightleftharpoons O_2 + H_2O$	
	$F_2 + 2H^+ + 2e^- \rightleftharpoons 2\,HF$	

Points to Remember

- The ratio of moles of MnO_4^- to moles of H_2O_2 consumed is different in acidic and basic solutions. This difference results from the fact that MnO_4^- is reduced all the way to Mn^{2+} in acid but the reaction stops at MnO_2 in base.
- Reactions in which a single reagent undergoes both oxidation and reduction are called **disproportionation reactions.** Bromine for example, disproportionates to form bromide and bromate ions when a strong base is added to an aqueous bromine solution.

$$Br_2 \xrightarrow{OH^-} Br^- + BrO_3^-$$

- Order of increasing reducing strength of some reducing agents.

$$HF < Cl^- < Cu < H_2 < Pb < Zn < H^-$$

- Order of increasing oxidising strength of some oxidising agents.

$$Na^+ < Cr^{3+} < H^+ < Cu^{2+} < O_2 < Cr_2O_7^{2-} < O_3.$$

- Equivalent weight of an oxidising agent = $\frac{\text{Molecular weight of oxidising agent}}{\text{Decrease in O.N. of an effective atom in 1 mol of oxidising agent} \times \text{No. of effective atoms}}$
- Equivalent weight of a reducing agent = $\frac{\text{Molecular weight of reducing agent}}{\text{Increase in O.N. of an effective atom in 1 mol of reducing agent} \times \text{No. of effective atoms}}$
- Some substances which are oxidising and reducing agents both : These are those substances in which oxidation state of element can be increased or decreased.

  Examples : SO_2, HNO_2, H_2SO_3, etc.

OBJECTIVE QUESTIONS

1. In which of the following compounds, the metal atom has fractional oxidation number ?
   (A) $[Ni(CO)_4]$ (B) Pb_3O_4
   (C) Mn_2O_3 (D) Fe_2O_3
2. Which of the following groups of Iodine compounds shows increasing order of oxidation number of iodine ?
   (A) HIO_4, ICl, I_2, HI
   (B) HI, I_2, ICl, HIO_4
   (C) I_2, HI, HIO_4, ICl
   (D) ICl, HIO_4, HI, I_2
3. Which one of the following is correct balanced reaction ?
   (A) $2\,MnO_4^- + H_2O_2 + 6\,H^+ \rightarrow 2\,Mn^{2+} + 3\,O_2 + 4\,H_2O$
   (B) $2\,MnO_4^- + 3\,H_2O_2 + 6\,H^+ \rightarrow 2\,Mn^{2+} + 4\,O_2 + 6\,H_2O$
   (C) $2\,MnO_4^- + 5\,H_2O_2 + 6\,H^+ \rightarrow 2\,Mn^{2+} + 5\,O_2 + 8\,H_2O$
   (D) $2\,MnO_4^- + 7\,H_2O_2 + 6\,H^+ \rightarrow 2\,Mn^{2+} + 6\,O_2 + 10\,H_2O$
4. Which one of the following is a metathesis reaction ?
   (A) $Hg_2^{2+} + 2\,OH^- \rightarrow Hg_2O + H_2O$
   (B) $Hg_2^{2+} + Sn^{2+} \rightarrow 2\,Hg + Sn^{4+}$
   (C) $Hg_2^{2+} + H_2S \rightarrow Hg + HgS + 2\,H^+$
   (D) None of these
5. The average oxidation number of iodine in I_3^- ion is—
   (A) -1 (B) $-\frac{1}{3}$
   (C) $+1$ (D) $+\frac{1}{3}$
6. Which of the following reactions is a redox reaction ?
   (A) $PCl_3 + 3\,H_2O \rightarrow H_3PO_3 + 3\,HCl$
   (B) $Co^{3+} + 6\,NO_2^- \rightarrow Co(NO_2)_6^{3-}$
   (C) $Hg_2CrO_4 + 2\,OH^- \rightarrow Hg_2O + CrO_4^{2-} + H_2O$
   (D) $Br_2 + OH^- \rightarrow Br^- + BrO_3^-$
7. In the redox reaction
   $Cu_{(s)} + 2\,Ag^+ \rightarrow Cu^{2+} + 2\,Ag.$
   the weakest oxidising agent and weakest reducing reagents are—
   (A) Cu^{2+} and Ag respectively
   (B) Ag and Cu^{2+} respectively
   (C) Ag^+ and Cu respectively
   (D) Ag^+ and Cu^{2+} respectively
8. Which of the following pairs of ions cannot coexist in aqueous solution ?
   (A) Cr^{2+} and MnO_4^-
   (B) Fe^{3+} and $Cr_2O_7^{2-}$
   (C) Cr^{2+} and I_3^-
   (D) Mn^{2+} and Cl^-
9. Which one of the following can be both an oxidising agent and a reducing agent ?
   (A) H_2 (B) I_2
   (C) H_2O_2 (D) All of these
10. Which of the following transition metals is strongest reducing agent ?
    (A) Cr (B) Mn
    (C) Ni (D) Co
11. Which of the following solutions is strongest oxidising agent ?
    (A) MnO_4^- in acid
    (B) MnO_4^- in base
    (C) MnO_2 in base
    (D) CrO_4^{2-} in base
12. Which one of the following cannot be a reducing agent ?.
    (A) Cl^- (B) CaH_2
    (C) Fe^{2+} (D) Br_2
13. Which of the following reactions is a redox reaction ?
    (A) $Ca_3P_2 + 6\,H_2O \rightarrow 3\,Ca(OH)_2 + 2\,PH_3$
    (B) $PH_3 + HCl \rightarrow PH_4Cl$
    (C) $PCl_3 + 3\,H_2O \rightarrow H_3PO_3 + 3\,HCl$
    (D) None of these

14. Which of the following species does not contain hydrogen in negative oxidation state ?
(A) $LiAlH_4$ (B) CaH_2
(C) NaH (D) N_3H

15. The oxidation number of underlined atom in the molecule $Fe_4[\underline{Fe}(CN)_6]_3$ is—
(A) + 3 (B) + 2
(C) + 1 (D) 0

16. The oxidation number of sulphur in $K_2S_2O_8$ is—
(A) + 2 (B) + 4
(C) + 7 (D) + 6

17. Which of the following compounds has lowest negative oxidation number of oxygen ?
(A) H_2O_2 (B) O_2F_2
(C) KO_2 (D) IF_2

18. The oxidation number of iron in $[Fe(H_2O)_5NO]SO_4$ is—
(A) + 3 (B) + 2
(C) + 1 (D) 0

19. Which of the following elements shows highest oxidation number in compounds ?
(A) Chlorine (B) Carbon
(C) Nitrogen (D) Oxygen

20. The reaction occurring at cathode is—
(A) Oxidation
(B) Reduction
(C) Hydrolysis
(D) None of these

21. The oxidation number of chromium in $CrO(O_2)_2$ is—
(A) + 10 (B) + 5
(C) + 6 (D) + 3

22. Compound $(NH_3)_3CrO_4$ is pentagonal bipyramidal in structure involving two peroxo linkages. The oxidation number of chromium atom is—
(A) 0 (B) + 2
(C) + 4 (D) + 6

23. Which of the following compounds is a product of metathesis reaction between concentrated solution of H_2SO_4 and saturated solution of $K_2Cr_2O_7$ and is known as chromic acid ?
(A) Cr_2O_5 (B) Cr_2O_3
(C) CrO_3 (D) CrO_2

24. Which of the following compounds shows – 1 oxidation state of Mn ?
(A) $[Mn(CO)_5]^-$
(B) $[Mn_2(CO)_{10}]$
(C) $K_6[Mn(CN)_6]\cdot 2NH_3$
(D) $K_5[Mn(CN)_6]$

25. Electrolytic oxidation of K_2MnO_4 leads to the formation of—
(A) $KMnO_4$
(B) Mn_2O_7
(C) MnO_4
(D) None of these

ANSWERS

1. (B) 2. (B) 3. (C) 4. (A) 5. (B)
6. (D) 7. (A) 8. (A) 9. (D) 10. (B)
11. (A) 12. (D) 13. (D) 14. (D) 15. (B)
16. (D) 17. (C) 18. (C) 19. (A) 20. (B)
21. (C) 22. (C) 23. (C) 24. (A) 25. (A)

●●●

CHEMISTRY

1. Carbon and oxygen are known to form two gaseous compounds. The carbon content in one is 42·8% while in other 27·27%. These observations show—
   (A) Law of constant proportions
   (B) Law of multiple proportions
   (C) Law of conservation of mass
   (D) Law of reciprocal proportions

2. The number of gram-atoms and gram-molecules in 25·4 mg of iodine will be—
   (A) 2×10^{-4} gm-atoms and 1×10^{-4} gm-molecules
   (B) 1×10^{-4} gm-atoms and 2×10^{-4} gm-atoms
   (C) $6{\cdot}02 \times 10^{23}$ gm-atoms and $3{\cdot}004 \times 10^{23}$ gm-molecules
   (D) 127·0 gm-atoms and 254.0 gm-molecules

3. $6{\cdot}02 \times 10^{20}$ molecules of a compound weigh 92 mg. The molecular mass of the substance is—
   (A) 9200·00 (B) 92000·00
   (C) 92·00 (D) 920·00

4. The density of water at 4°C is 1·0 gm cm^{-3}. The volume occupied by $3{\cdot}01 \times 10^{24}$ molecules of water is—
   (A) 180 cm^3 (B) 90·0 cm^3
   (C) 45·0 cm^3 (D) 18·0 cm^3

5. A complex of iron contains 45·6% iron by mass. The number of iron atoms in 5·00 gm of this complex will be—
   (A) $2{\cdot}45 \times 10^{22}$
   (B) $24{\cdot}50 \times 10^{22}$
   (C) $2{\cdot}55 \times 10^{23}$
   (D) $25{\cdot}50 \times 10^{23}$

6. Two flasks A and B of equal capacity contain 10 gm of oxygen and ozone each. Under similar conditions which one of the following statements is correct ?
   (A) Both A and B have same number oxygen atoms
   (B) Both A and B have same number of molecules
   (C) B will have more number of molecules than A
   (D) The number of atoms and molecules will be same in both the flasks

7. 80 gm of hydrogen (H_2) is made to react with 80 gm of oxygen (O_2). The mass of water formed will be—
   (A) 80·00 gm (B) 90·00 gm
   (C) 36·00 gm (D) 72·00 gm

8. What volumes of 6M HCl and 2M HCl should be mixed to get one litre of 3M HCl solution ?
   (A) 0·25 lit. 6M and 0·75 lit. 2M HCl
   (B) 200 ml 6M and 800 ml 2M HCl
   (C) 0·75 lit. 6M and 0·25 lit. 2M HCl
   (D) 800 ml 6M and 200 ml 2M HCl

9. Fuse wire contains—
   (A) Cu and Ni
   (B) Pb and Sn
   (C) Cu and Sn
   (D) Pb and Be

10. Commercially available concentrated hydrochloric acid contains 38% of HCl by mass and its density is 1·19 gm cm^{-3}. The molarity of this solution is—
    (A) 18 M (B) 24·8 M
    (C) 12·4 M (D) 17 M

11. Which one of the following substances is used as Jewellers rouge ?
    (A) Haematite
    (B) Boron nitride
    (C) Silicon carbide
    (D) Graphite

12. The natural gas, methane reacts with oxygen as
    $$CH_{4(g)} + 2O_{2(g)} \rightarrow CO_{2(g)} + 2H_2O_{(g)}.$$
    The heat given off, when 0·16 gm of methane reacts with excess of oxygen in a bomb calorimeter with heat capacity of 958 J/°C, if the temperature of 1·00 kg of water in the bath surrounding the bomb increases by 1·56 K, will be—
    (Given C_{water} = 75·376 J/mol-K)
    (A) –802 kJ/mol
    (B) –80·20 kJ/mol
    (C) –0·958 kJ/mol
    (D) –9·58 kJ/mol

13. Which one of the following is an incorrect statement ?
    (A) The heat given off or absorbed when the reaction is run at constant volume is equal to change in internal energy
    (B) The heat given off or absorbed when the reaction is run at constant pressure is equal to change in enthalpy
    (C) The change in enthalpy during a change is equal to change in internal energy
    (D) The difference between ΔH and ΔE for a system is relatively small for reactions that involve liquids or solids

14. For which one of the following reactions, ΔH is roughly equal to ΔE ?
    (A) $CaCO_{3(s)} \rightarrow CaO_{(s)} + CO_{2(g)}$
    (B) $2NH_{3(g)} \rightarrow N_{2(g)} + 3H_{2(g)}$
    (C) $Fe_2O_{3(s)} + 2Al_{(s)} \rightarrow Al_2O_{3(s)} + 2Fe_{(s)}$
    (D) None of these

15. Which one of the following is an exothermic change ?
    (A) $H_2O_{(s)} \rightarrow H_2O_{(l)}$
    (B) $H_2O_{(l)} \rightarrow H_2O_{(g)}$
    (C) $H_2O_{(g)} \rightarrow H_2O_{(l)}$
    (D) None of these

16. The standard-state molar enthalpies of the reaction for the formation of water as both a liquid and a gas have been measured as
    $$H_{2(g)} + \frac{1}{2}O_{2(g)} \rightarrow H_2O_{(l)};$$
    Here, $\Delta H^0 = -285{\cdot}83$ kJ/mol
    $$H_{2(g)} + \frac{1}{2}O_{2(g)} \rightarrow H_2O_{(g)};$$

Here, $\Delta H^0 = -241{\cdot}82$ kJ/mol.

ΔH^0 for the change

$H_2O_{(l)} \rightarrow H_2O_{(g)}$ will be—

(A) −241·82 kJ/mol

(B) 241·82 kJ/mol

(C) 44·01 kJ/mol

(D) −44·01 kJ/mol

17. Which one of the following compounds transforms baking soda into baking powder ?

(A) $NaHCO_3$ (B) $KHCO_3$

(C) $KHC_4H_4O_6$ (D) KCl

18. Compound which is used in manic-depressive patients, is—

(A) $MgCO_3$

(B) Li_2CO_3

(C) $MgSO_4{\cdot}7H_2O$, $Mg(OH)_2$

(D) $Ca_5(PO_4)_3OH$

19. The principal component of both bone and tooth enamel is hydroxyapatite, $Ca_5(PO_4)_3OH$. The idea behind adding fluorides to toothpastes is to—

(A) Increase the flexibility of enamel

(B) Protect gums from bacteria

(C) Convert hydroxyapatite into $Ca_5(PO_4)_3F$

(D) Increase the lubrication of toothpaste

20. Electromagnetic waves with maximum wavelength are—

(A) Ultraviolet radiations

(B) Radiowaves

(C) X-rays

(D) Infrared radiations

21. The ratio of U^{238} to Ra^{226} atoms in the natural uranium is—

(Given are :

$t_{1/2}$ for $U^{238} = 4{\cdot}49 \times 10^9$ years and $t_{1/2}$ for $Ra^{226} = 1622$ years)

(A) 277 : 1

(B) $2{\cdot}77 \times 10^6 : 1$

(C) $1 : 2{\cdot}77 \times 10^6$

(D) 1: 277

22. Total number of alpha (α) and beta (β) particles emitted in the disintegration of $_{90}Th^{232}$ to $_{82}Pb^{208}$ will be—

(A) 6α and 4β (B) 4α and 6β

(C) 7α and 3β (D) 3α and 7β

23. A piece of wood was found to have $\frac{C^{14}}{C^{12}}$ ratio 0·7 times that in a living plant. The period when the plant died, is— (Half-life of C^{14} = 5760 year)

(A) 2967 year

(B) 2880 year

(C) 5760 year

(D) 29700 year

24. Sodium extract of an organic compound gives dark red colour with ferric chloride. The compound contains—

(A) Nitrogen

(B) Sulphur

(C) A and B both

(D) None of these

25. Boiling point of a liquid can be increased by—

(A) Increasing pressure

(B) Decreasing pressure

(C) Purifying liquid

(D) Mixing water

26. Which of the following compounds on acetylation gives acetyl salicylic acid ?

(A) *o*-dihydroxy benzene

(B) *o*-hydroxy benzoic acid

(C) *m*-hydroxy benzoic acid

(D) *p*-dihydroxy benzene

27. Which one of the following esters will not give claisen condensation reaction ?

(A) $C_6H_5COOC_2H_5$

(B) $C_6H_5CH_2COOC_2H_5$

(C) $C_3H_7CH_2COOC_2H_5$

(D) $HCOOC_2H_5$

28. Which one of the following compounds will undergo electrophilic substitution reaction most faster ?

(A) Benzene

(B) Toluene

(C) Chlorobenzene

(D) Phenol

29.  when reacts with R-MgX gives an intermediate product (A) which on hydrolysis yields final product (B). The product B is—

(A) R_2CHCH_2OH

(B) $RCHOHCH_3$

(C) RCH_2CH_2OH

(D) RCHOHR

30. Which one of the following ions gives coloured aqueous solution ?

(A) Zn^{2+} (B) Cu^+

(C) Cr^{3+} (D) Ti^{4+}

31. Which one of the following is not related with arene compounds ?

(A) They are stable

(B) They involve delocalisation of π electrons

(C) They involve resonance

(D) They undergo electrophilic addition reactions

32. Which one of the following metals cannot be extracted without using cryolite ?

(A) Tin (B) Magnesium

(C) Aluminium (D) Lead

33. The compound which behaves as a covalent compound, is—

(A) $BaCl_2$ (B) CsCl

(C) $AlCl_3$ (D) $PbCl_2$

34. The rate expression of a reaction is given as

$$\text{Rate} = KC_A^{3/2} C_B^{-1/2}$$

The order of the reaction will be—

(A) $\frac{3}{2}$ (B) $-\frac{1}{2}$

(C) 1 (D) 2

35. Which one of the following electronic configurations does not belong to alkaline earth metals ?

(A) $[Kr]5s^2$

(B) $[Xe]6s^2$

(C) $[Ar]3d^{10}4s^2$

(D) $[Rn]7s^2$

36. Compounds which decompose on their boiling point are distilled—

(A) By fractional distillation

(B) By steam distillation

(C) Under reduced pressure

(D) By simple distillation

37. In the reaction

$Cu + 2H_2SO_4 \rightarrow CuSO_4 + SO_2 + 2H_2O$.

H_2SO_4 acts as a—

(A) Reducing agent

(B) Oxidising agent

(C) Dehydrating agent
(D) All of these

38. Which one of the following compounds will have highest boiling point ?
(A) *n*-pentane
(B) *n*-octane
(C) 2, 2, 3, 3-tetramenthyl butane
(D) Iso-octane

39. Which one of the following compounds is used as automobile antifreeze in cold countries ?
(A) 1, 2 ethanediol
(B) Tert. butanol
(C) Both of these
(D) None of these

40. 0·1 gm of a compound of empirical formula CH_2F_2 occupies 0·047 lit. at 298 K and 755 mm of Hg. The molar mass of the compound is—
(A) 52·4 gm/mol
(B) 24·5 gm/mol
(C) 42·5 gm/mol
(D) 25·4 gm/mol

41. According to the reaction

$$2Al + 2NaOH + 6H_2O \rightarrow 2NaAl(OH)_4 + 3H_2\uparrow.$$

If 5·6 gm of Al powder and excess of NaOH were used, how many litres of hydrogen measured at 742 mm of Hg and 22·0°C were produced ?
(A) 5·6 litre (B) 7·7 litre
(C) 77·0 litre (D) 0·77 litre

42. 22 gm of propane and 11 gm of isobutane were mixed together and the mixture was then forced into a can until the total pressure was 1·5 atm. The partial pressure of propane and isobutane are—
(A) 1·1 atm. and 0·42 atm.
(B) 0·42 atm. and 1·1 atm.
(C) 1·1 atm. and 2·2 atm.
(D) 1·1 atm. and 0·22 atm.

43. Which one of the following is a wrong expression ?
(A) $\dfrac{\text{Rate of effusion of gas A}}{\text{Rate of effusion of gas B}} = \sqrt{\dfrac{\text{M of gas B}}{\text{M of gas A}}}$

(B) $\dfrac{\text{Rate of effusion of gas A}}{\text{Rate of effusion of gas B}} = \sqrt{\dfrac{3RT/(\text{M of gas A})}{3RT/(\text{M of gas B})}}$

(C) $\dfrac{\text{Rate of effusion of gas A}}{\text{Rate of effusion of gas B}} = \sqrt{\dfrac{3RT/(\text{M of gas B})}{3RT/(\text{M of gas A})}}$

(D) $\dfrac{\text{Rate of effusion of gas A}}{\text{Rate of effusion of gas B}} = \sqrt{\dfrac{\sqrt{\overline{v^2}} \text{ of gas A}}{\sqrt{\overline{v^2}} \text{ of gas B}}}$

44. Which one of the following terms in the van der Waal's equation corresponds to the correction for intermolecular forces ?
(A) $\left(\frac{n}{V}\right)^2$ (B) $a\left(\frac{n}{V}\right)^2$
(C) bn (D) $\left(a \times \frac{n}{V}\right)^2$

45. Which one of the following ions has very high hydration energy ?
(A) Na^+ (B) K^+
(C) Mg^{2+} (D) Cs^+

46. 1·0 litre of water is placed in a small room that has volume of $2{\cdot}30 \times 10^4$ lit. About how much water will evaporate at 25°C ?
(Density of water = 0·997 gm/cm^3 and vapour pressure of water at 25°C is 23·8 mm Hg)
(A) All water will evaporate
(B) About half of the water will evaporate
(C) About $\frac{1}{4}$ th of the water will evaporate
(D) None of these is correct

47. Which one of the following compounds is non-stoichiometric and semiconductor ?
(A) Cadmium sulphide
(B) Sodium chloride
(C) Quartz
(D) Ice

48. The radius of the Na^+ ion is 116 pm and the radius of Cl^- ion is 167 pm. The volume of unit cell in pm^3 is—
(A) $1{\cdot}81 \times 10^8$ pm^3
(B) $18{\cdot}1 \times 10^8$ pm^3
(C) $8{\cdot}11 \times 10^8$ pm^3
(D) $11{\cdot}8 \times 10^8$ pm^3

49. Which one of the following compounds has highest lattice energy ?
(A) LiF (B) CsF
(C) RbF (D) NaF

50. Oxygen has a Henry's law constant of $1{\cdot}7 \times 10^{-6}$ molal per mm Hg when dissolved in water at 25°C. What is the concentration of O_2 in water at 25°C, when O_2 has partial pressure of 150 mm Hg ?
(A) 8·8 mg of O_2 in one kg of water
(B) 88·0 mg of O_2 in one kg of water
(C) About 8·0 mg of O_2 in one kg of water
(D) 0·8 gm of O_2 in one kg of water

ANSWERS

1. (B) 2. (A) 3. (C) 4. (B) 5. (A)
6. (A) 7. (B) 8. (A) 9. (B) 10. (C)
11. (A) 12. (A) 13. (C) 14. (C) 15. (C)
16. (C) 17. (C) 18. (B) 19. (C) 20. (B)
21. (B) 22. (A) 23. (A) 24. (C) 25. (A)
26. (B) 27. (A) 28. (D) 29. (C) 30. (C)
31. (D) 32. (C) 33. (C) 34. (C) 35. (C)
36. (C) 37. (B) 38. (B) 39. (A) 40. (A)
41. (B) 42. (A) 43. (C) 44. (B) 45. (C)
46. (B) 47. (A) 48. (A) 49. (A) 50. (C)

HINTS

1. In first compound
Carbon = 42·8%
Oxygen = (100 – 42·8)
= 57·2%
In second compound
Carbon = 27·27%
Oxygen = (100 – 27·27)
= 72·73%
In first compound the number of parts by mass of oxygen that combines with one part by mass of carbon
$$\frac{57{\cdot}2}{42{\cdot}8} = 1{\cdot}33$$
In second compound the number of parts by mass of oxygen that

combines with one part by mass of carbon

$$\frac{72\cdot73}{27\cdot27} = 2\cdot66$$

The ratio of masses of oxygen that combines with fixed mass (1 part) by mass of carbon is

$$1\cdot33 : 2\cdot66$$
$$1 : 2$$

Since, the ratio is a simple whole number ratio, hence it illustrates the law of multiple proportions.

2. Gram atoms of iodine

$$= \frac{\text{Mass (g)}}{\text{G.A.M}}$$
$$= \frac{25\cdot4 \times 10^{-3}\text{g}}{127\text{g}}$$
$$= 2 \times 10^{-4} \text{ gm-atoms}$$

Gram-molecules of iodine

$$= \frac{\text{Mass in (g)}}{\text{G.M.M}}$$
$$= \frac{25\cdot4 \times 10^{-3}\text{g}}{254\text{g}}$$
$$= 1 \times 10^{-4} \text{ gm-molecules}$$

3. 92 mg = 92×10^{-3} gm

$\because$ $6\cdot02 \times 10^{20}$ molecules weigh

$$= 92 \times 10^{-3} \text{ gm}$$

$\therefore$ $6\cdot02 \times 10^{23}$ molecules will weigh

$$= \frac{92 \times 10^{-3} \times 6\cdot02 \times 10^{23}}{6\cdot02 \times 10^{20}}$$
$$= 92 \times 10^{-3} \times 10^{3}$$
$$= 92$$

Hence, molecular mass is 92.

4. $\because$ $6\cdot02 \times 10^{23}$ water molecules will weigh = 18 gm

$\therefore$ $3\cdot01 \times 10^{24}$ water molecules will weigh

$$= \frac{18 \times 3\cdot01 \times 10^{24}}{6\cdot02 \times 10^{23}}$$
$$= 90\cdot00 \text{ gm}$$

Since, density of water is $1\cdot0 \text{ gm cm}^{-3}$

Hence, 1·0 gm = 1 cm^3

$\therefore$ 90·00 gm = 90 cm^3

Hence, volume will be 90 cm^3.

5. $\because$ 100 gm of iron complex contains = 45·6 gm of iron

$\therefore$ 5 gm of iron complex will contain

$$= \frac{45\cdot6 \times 5}{100} \text{ gm of iron}$$
$$= 2\cdot28 \text{ gm of iron}$$

Now,

$\because$ 56 gm of iron contains

$$= 6\cdot023 \times 10^{23} \text{ atoms}$$

$\therefore$ 2·28 gm of iron will contain

$$= \frac{6\cdot023 \times 10^{23} \times 2\cdot28}{56}$$
$$= 2\cdot45 \times 10^{22} \text{ atoms}$$

6. Molecular mass of oxygen = 32

Molecular mass of ozone = 48

Now,

$\because$ 32 gm of oxygen have

$2 \times 6\cdot02 \times 10^{23}$ oxygen atoms

$\therefore$ 10 gm of oxygen will have

$$= \frac{2 \times 6\cdot02 \times 10^{23} \times 10}{32}$$
$$= \frac{6\cdot02 \times 10^{24}}{16} \text{ atoms}$$

Similarly,

$\because$ 48 gm of ozone have

$3 \times 6\cdot02 \times 10^{23}$ oxygen atoms

$\therefore$ 10 gm of ozone will have

$$= \frac{3 \times 6\cdot02 \times 10^{23} \times 10}{48}$$
$$= \frac{6\cdot02 \times 10^{24}}{16} \text{ atoms}$$

Hence, number of oxygen atoms will be same in both flasks

Again,

$\because$ 32 gm of oxygen have

$= 6\cdot02 \times 10^{23}$, O_2 molecules

$\therefore$ 10 gm of oxygen will have

$$= \frac{6\cdot02 \times 10^{23} \times 10}{32}$$
$$= \frac{6\cdot02 \times 10^{24}}{32} \text{ molecules of } O_2$$

Similarly,

$\because$ 48 gm of ozone have

$= 6\cdot02 \times 10^{23}$, O_3 molecules

$\therefore$ 10 gm of ozone will have

$$= \frac{6\cdot02 \times 10^{23} \times 10}{48}$$
$$= \frac{6\cdot02 \times 10^{24}}{48}$$

Then $\frac{6\cdot02 \times 10^{24}}{32} > \frac{6\cdot02 \times 10^{24}}{48}$

Hence, flask A will have higher number of molecules

7. According to reaction

$$2H_2 + O_2 \longrightarrow 2H_2O$$
4·0 gm 32·0 gm 36·0 gm

Here, oxygen is a limiting reactant. Therefore,

$\because$ 32 gm oxygen gives 36·0 gm of water

$\therefore$ 80 gm oxygen will give

$$= \frac{36 \times 80}{32}$$
$$= 90\cdot00 \text{ gm of water}$$

Hence, 90·00 gm of water will be formed.

8. Suppose the volume of 6M HCl required to obtain 1 litre of 3 M HCl = x litre.

Therefore,

The volume of 2M HCl required

$$= (1 - x) \text{ litre}$$

Applying the molarity equation

$$\underset{\text{6M HCl}}{M_1V_1} + \underset{\text{2M HCl}}{M_2V_2} = \underset{\text{3M HCl}}{M_3V_3}$$

$$6x + 2(1 - x) = 3 \times 1$$
$$6x + 2 - 2x = 3$$
$$4x = 3 - 2 = 1$$
$$\therefore \quad x = \frac{1}{4}$$
$$= 0\cdot25 \text{ litre}$$

Hence, volume of 6M HCl required = 0·25 litre

Volume of 2M HCl required

$$= (1 - 0\cdot25)$$
$$= 0\cdot75 \text{ litre}$$

10. Mass of 1000 cm^3 of commercial HCl = $1000 \times 1\cdot19$

$$= 1190 \text{ gm}$$

Now, the mass of HCl in 1190 gm of HCl solution

$$= \frac{1190 \times 38}{100}$$
$$= 452\cdot20 \text{ gm}$$

Molar mass of HCl

$$= 36\cdot5 \text{ gm}$$

Hence, no. of mole of HCl in 1000 cm^3

$$= \frac{452\cdot20}{36\cdot50}$$
$$= 12\cdot4 \text{ moles}$$

Hence, molarity of HCl solution

$$= 12\cdot4 \text{ M}$$

11. Jewellers rouge is a red powdered haematite which is a mild abrassive used in metal cleaning and polishing.

12. Moles of water which capture the heat

$$= \frac{1000\text{g}}{18\cdot02\text{g}}$$
$$= 55\cdot49 \text{ mole}$$

$\therefore \quad q_{water} = nC\Delta T$

$= (55{\cdot}49 \text{ mol}) \times (75{\cdot}376 \text{ J/mol-K}) \times (1{\cdot}56 \text{ K})$

$= 6525 \text{ J}$

Heat absorbed by bomb is calculated as

$q_{bomb} = C\Delta T$

$= (958 \text{J/°C}) \times (1{\cdot}56 \text{°C})$

$= 1494 \text{ J}$

Total heat absorbed is given as

$6525 + 1494 = 8019 \text{ J}$

We can, therefore, conclude that the reaction gives off 8·02 kJ of energy in the form of heat.

$q_{reaction} = -8{\cdot}02 \text{ kJ}$

Since, 0·16 gm of methane corresponds to 0·01 moles of methane

$\therefore -\frac{8{\cdot}02 \text{ kJ}}{0{\cdot}01 \text{ mol}} = -802 \text{ kJ/mol.}$

14. For reaction (C), there is no significant change in the volume because, the reactants and products are solids. Therefore, ΔH and ΔE will be roughly equal for this reaction.

15. Reaction (C) is exothermic because it is the opposite of the (A) and (B) reactions. The steam causes more severe burns than hot water because it also releases heat to the skin as it condenses to form the liquid.

16. According to Hess's Law

$$H_2O_{(l)} \rightarrow H_{2\,(g)} + \frac{1}{2}O_{2(g)}$$

$$\Delta H^0 = 285{\cdot}83 \text{ kJ/mol}$$

$$H_{2(g)} + \frac{1}{2}O_{2(g)} \rightarrow H_2O_{(g)}$$

$$\Delta H^0 = -241{\cdot}82 \text{ kJ/mol}$$

$$H_2O_{(l)} \rightarrow H_2O_{(g)},\ \Delta H^0 = 44{\cdot}01 \text{ kJ}$$

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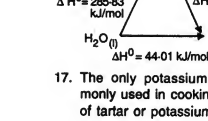
or



17. The only potassium salt commonly used in cooking is cream of tartar or potassium hydrogen tartrate ($KHC_4H_4O_6$) which is used to transform baking soda ($NaHCO_3$) into baking powder.

19. Main component of tooth and bone enamel is hydroxyapatite $Ca_5(PO_4)_3OH$. Fluorides to tooth pastes are added to convert $Ca_5(PO_4)_3OH$ into $Ca_5(PO_4)_3F$ because it is harder and more resistant to decay.

21. $\frac{N_1}{N_2} = \frac{(t_{1/2})_1}{(t_{1/2})_2}$

$= \frac{4{\cdot}49 \times 10^9}{1622}$

$= 2{\cdot}77 \times 10^6$

The ratio of U^{238} to Ra^{226}

$= 2{\cdot}77 \times 10^6 : 1$

22. Let the number of α-particles emitted

$= a$

and number of β-particles emitted

$= b$

Here, $4a = 232 - 208$

$a = \frac{24}{4} = 6$

Hence, α-particles = 6

Similarly,

$2a - b = 90 - 82$

$-b = -2a + 8$

$\Rightarrow \quad b = 2a - 8$

$\Rightarrow \quad b = 2 \times 6 - 8$

$b = 4$

Hence, β-particles = 4

23. Here, $N_0 = 1$

$N_t = 0{\cdot}70$

$t_{1/2} = 5760 \text{ year}$

Calculation of $K = \frac{0{\cdot}693}{t_{1/2}}$

$= \frac{0{\cdot}693}{5760}$

We know that

$K = \frac{2{\cdot}303}{t} \log \frac{N_0}{N_t}$

$\frac{0{\cdot}693}{5760} = \frac{2{\cdot}303}{t} \log \frac{1}{0{\cdot}70}$

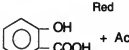
$t = \frac{2{\cdot}303 \times 5760 \times 0{\cdot}155}{0{\cdot}693}$

$= 2967 \text{ year}$

24. When N and S both are present in an organic compound, it gives NaCNS when fused with sodium. NaCNS on reacting with $FeCl_3$ gives deep red coloured $Fe(CNS)_3$.

$3\,NaCNS + FeCl_3 \rightarrow Fe(CNS)_3 + 3\,NaCl$

Red

26. 

o-hydroxy benzoic acid or Salicylic acid

Acetyl Salicylic acid or Aspirin

27. Reaction in which two ester molecules having α-hydrogen atoms react together in presence of sodium ethoxide to give keto ester, is known as Claisen condensation reaction.

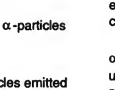
$C_6H_5COOC_2H_5$ does not have α-hydrogen atoms and it will not undergo Claisen condensation reaction. Claisen condensation reaction is as—

$CH_3COOC_2H_5 +$

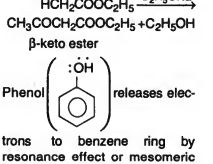
$HCH_2COOC_2H_5 \xrightarrow{C_2H_5ONa}$

$CH_3COCH_2COOC_2H_5 + C_2H_5OH$

β-keto ester

28. Phenol 

releases electrons to benzene ring by resonance effect or mesomeric effect more effectively. Electron release by :$\ddot{O}$H group stabilises the carbocation more effectively and hence activates the aromatic ring for electrophilic substitution.

29. 

34. $\text{Rate} = K C_A^{3/2} C_B^{-1/2}$

Order of the reaction will be

$\frac{3}{2} - \frac{1}{2} = \frac{2}{2} = 1$

40. We know that

$n = \frac{PV}{RT}$

$$P = 755 \text{ mm} \left(\frac{1 \text{ atm.}}{760 \text{ mm}}\right)$$

$$= 0{\cdot}993 \text{ atm.}$$

$$\therefore n = \frac{(0{\cdot}993 \text{ atm})\,(0{\cdot}047 \text{ lit})}{(0{\cdot}082057 \text{ lit atm/K-mol})\,(298 \text{ K})}$$

$$= 0{\cdot}00191 \text{ mole}$$

Hence, molar mass

$$= \frac{0{\cdot}1 \text{ gm}}{0{\cdot}00191 \text{ mole}}$$

$$= 52{\cdot}4 \text{ gm/mole}$$

Alternately :

$$\text{Density } (d) = \frac{PM}{RT}$$

$$\left\{ d = \frac{0{\cdot}10}{0{\cdot}047} = 2{\cdot}13 \text{ gm/lit} \right\}$$

$$M = \frac{d\,RT}{P}$$

$$= \frac{(2{\cdot}13 \text{ gm/lit})\,(0{\cdot}082057 \text{ lit atm/K-mole})\,(298\text{K})}{0{\cdot}993 \text{ atm}}$$

$$= 52{\cdot}5 \text{ gm/mole}$$

(This molar mass is equal to the empirical formula weight).

41. Moles of Al

$$= 5{\cdot}6 \text{ gm Al} \left(\frac{1{\cdot}0 \text{ mole Al}}{27{\cdot}0 \text{ gm Al}}\right)$$

$$= 0{\cdot}21 \text{ mole of Al}$$

Moles of H_2 produced by aluminium

$$= 0{\cdot}21 \text{ mole Al} \left(\frac{3 \text{ mole of } H_2}{2 \text{ mole of Al}}\right)$$

$$= 0{\cdot}31 \text{ mole of } H_2$$

Now, from

$$PV = nRT$$

$$\therefore V = \frac{nRT}{P}$$

$$= \frac{(0{\cdot}31 \text{ mole})\,(0{\cdot}082057 \text{ lit-atm/K mole})\,(295\text{K})}{(0{\cdot}976 \text{ atm})}$$

($\because$ 742 mm = 0·976 atm.)

$$= 7{\cdot}7 \text{ lit of } H_2$$

42. Moles of C_3H_8

$$= 22 \text{ gm } C_3H_8 \left(\frac{1{\cdot}0 \text{ mol } C_3H_8}{44{\cdot}1 \text{ gm } C_3H_8}\right)$$

$$= 0{\cdot}5 \text{ mole}$$

Moles of C_4H_{10}

$$= 11 \text{ gm } C_4H_{10} \left(\frac{1{\cdot}0 \text{ mole of } C_4H_{10}}{58{\cdot}1 \text{ gm } C_4H_{10}}\right)$$

$$= 0{\cdot}19 \text{ mole}$$

Mole fraction of C_3H_8

$$= \frac{0{\cdot}5 \text{ mole } C_3H_8}{0{\cdot}69 \text{ Total moles}} = 0{\cdot}72$$

Since,

$$X_{C_3H_8} + H_{C_4H_{10}} = 0{\cdot}72 + X_{C_4H_{10}}$$

$$\therefore \quad 1 = 0{\cdot}72 + X_{C_4H_{10}}$$

$$\therefore X_{C_4H_{10}} = 1 - 0{\cdot}72 = 0{\cdot}28$$

Now,

Partial pressure of C_4H_{10}

$$= 0{\cdot}28 \times P_{Total}$$

$$= 0{\cdot}28\ (1{\cdot}5 \text{ atm})$$

$$= 0{\cdot}42 \text{ atm}$$

$$P_{C_3H_8} + P_{C_4H_{10}} = 1{\cdot}5 \text{ atm}$$

$$\therefore P_{C_3H_8} = 1{\cdot}5 \text{ atm} - 0{\cdot}42 \text{ atm}$$

$$= 1{\cdot}1 \text{ atm}$$

46. The approach to solving this problem is to calculate the amount of water that must evaporate in order to exert a pressure of 23·8 mm Hg in a volume of $2{\cdot}30 \times 10^4$ lit at 25°C

$$n \text{ moles} = \frac{PV}{RT}$$

$$= \frac{\left(\frac{23{\cdot}8 \text{ mm Hg}}{760 \text{ mm Hg/atm}}\right)(2{\cdot}30 \times 10^4 \text{ lit})}{(0{\cdot}0821 \text{ lit-atm/K-mole})\,(298 \text{ K})}$$

$$n = 29{\cdot}4 \text{ moles of } H_2O$$

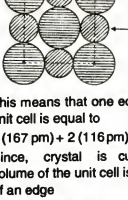
$$29{\cdot}4 \text{ (mole of } H_2O) \left(\frac{18{\cdot}02 \text{ gm}}{0{\cdot}997 \text{ gm}}\right)$$

$$= 531 \text{ gm}$$

$$531 \text{ gm} \left(\frac{1 \text{ cm}^3}{0{\cdot}997 \text{ gm}}\right) = 532 \text{ cm}^3$$

Thus, nearly half of the water will evaporate in order to achieve an equilibrium at 23·8 mm Hg and 25°C.

48. One face of the face centered NaCl unit cell will look as—



This means that one edge of the unit cell is equal to

2 (167 pm) + 2 (116 pm) = 566 pm

Since, crystal is cubic, the volume of the unit cell is the cube of an edge

Volume of unit cell

$$= (\text{edge})^3$$

$$= (566 \text{ pm})^3$$

$$= 1{\cdot}81 \times 10^8 \text{ pm}^3$$

50. From Henry's law, we have

Molarity of O_2

$$= (1{\cdot}7 \times 10^{-6} \text{ molal/mm Hg})\,(150 \text{ mm Hg})$$

$$= 2{\cdot}6 \times 10^{-4} \text{ m}$$

$\because$ When molality is 1, then the oxygen weighs 32 gm

$\therefore$ When molality is $2{\cdot}6 \times 10^{-4}$, the oxygen will weigh

$$= 32 \times 2{\cdot}6 \times 10^{-4}$$

$$= 83{\cdot}2 \times 10^{-4} \text{ gm}$$

$$83{\cdot}2 \times 10^{-4} \text{ gm}$$

$$= 83{\cdot}2 \times 10^{-4} \times 1000$$

$$= 8{\cdot}32 \text{ mg}$$

Hence, nearly 8·0 mg of oxygen is dissolved in 1 kg of water.

●●●

CHEMISTRY

1. When the value of $n + l$ is not more than three which of the following sub-shells is not possible to exist ?
   (A) 2*s* (B) 3*s*
   (C) 3*p* (D) 2*p*

2. The ionization energy of hydrogen atom is 13·6 eV. The ionization energy of Li^{2+} ion will be—
   (A) 13·6 eV (B) 40·8 eV
   (C) 122·4 eV (D) 84·6 eV

3. The energy required to send hydrogen electron from $n = 1$ to $n = 2$ will be—
   (A) 13·6 eV (B) 27·2 eV
   (C) 10·2 eV (D) 1·02 eV

4. The reaction of benzaldehyde with ammonia (NH_3) gives—
   (A) Benzaldehyde ammonia
   (B) Benzaldimine
   (C) Hydrobenzamide
   (D) Benzamide

5. The product formed by heating sodium phenoxide with CO_2 at 140°C on treatment with HCl gives—
   (A) Phenyl acetic acid
   (B) Cinnamic acid
   (C) Benzoic acid
   (D) Salicylic acid

6. The reaction
   $$C_6H_6 \xrightarrow[AlCl_3]{CO + HCl} C_6H_5CHO$$
   is known as—
   (A) Reimer—Tiemann reaction
   (B) Perkin's reaction
   (C) Gattermann Koch reaction
   (D) Gattermann aldehyde synthesis

7. When the vapours of benzene are passed through a red hot tube—
   (A) Diphenyl is formed
   (B) Diphenyl benzene is formed
   (C) Both A and B are correct
   (D) Both A and B are wrong

8. Which of the following compounds is not reduced by ozone ?
   (A) BaO_2
   (B) Ag_2O
   (C) Na_2O_2
   (D) $K_4[Fe(CN)_6]$

9. Which of the following oxyacids of phosphorus is monobasic and reducing in nature ?
   (A) Metaphosphoric acid
   (B) Pyrophosphoric acid
   (C) Hypophosphoric acid
   (D) Hypophosphorus acid

10. When cupric oxide (CuO) is heated in the current of ammonia, which of the following is not the product formed ?
    (A) Cu (B) N_2
    (C) H_2O (D) Cu_3N_2

11. Which of the following species has the lowest value for pK_a ?
    (A) H_3PO_4
    (B) $H_2PO_4^-$
    (C) HPO_4^{2-}
    (D) All have equal value

12. When ammonia (NH_3) reacts with calcium hypochlorite, which of the following is main product of the reaction ?
    (A) Ca_3N_2 (B) NH_4Cl
    (C) N_2 (D) CaO

13. Which of the following metals has the lowest metallic conductivity ?
    (A) Silver (B) Copper
    (C) Sodium (D) Zinc

14. Reduction potentials of some half reactions are given as :
    $Fe^{2+} + 2e \rightarrow Fe$; $E^0 = -0.47$ volts
    $Fe^{3+} + 3e \rightarrow Fe$; $E^0 = -0.057$ volts
    $Fe^{3+} + e \rightarrow Fe^{2+}$; $E^0 = +0.77$ volts
    $FeO_4^{2-} + 3e + 8H^+ \rightarrow Fe^{3+} + 4H_2O$; $E^0 = +2.20$ volts
    Which of the following statements is correct ?
    (A) Neither Fe^{3+} nor Fe^{2+} have any tendency to reduce to Fe
    (B) FeO_4^{2-} is the weakest oxidising agent
    (C) ΔG value for $FeO_4^{2-} \rightarrow Fe^{3+}$ will be large and positive
    (D) Reactions with negative values for E^0 are more strongly oxidising than oxygen

15. Didymium catalyst is—
    (A) Neodymium
    (B) Praseodymium
    (C) Both (A) and (B)
    (D) None of these

ANSWERS WITH HINTS

1. (C)	2. (C)	3. (C)	4. (C)	5. (D)	1 + 0 = 1 means 1*s* sub-shell
6. (C)	7. (C)	8. (D)	9. (D)	10. (D)	For $n + l = 2$
11. (A)	12. (C)	13. (D)	14. (A)	15. (C)	2 + 0 = 2 means 2*s* sub-shell
					For $n + l = 3$
					3 + 0 = 3 means 3*s* sub-shell
					2 + 1 = 3 means 2*p* sub-shell
					Hence, 3*p* sub-shell is not possible

1. The value of $n + l$ may be upto 3
   $n + l = 1$; $n + l = 2$; $n + l = 3$
   For $n + l = 1$

2. Ionization energy of H atom is given as

$$\text{I. E.} = 13{\cdot}6 \times \frac{Z^2}{n^2}\ \text{eV}$$

Hence ionization energy of Li^{2+} will be as

$$\text{I. E.} = \frac{13{\cdot}6 \times (3)^2}{1^2}$$

$$= 122{\cdot}4\ \text{eV}$$

(Z = 3 for Lithium)

3. Sending an electron from $n = 1$ to $n = 2$ is known as first excitation potential

1st excitation potential

$$= E_2 - E_1$$

$$E_1 = -13{\cdot}6\ \text{eV}$$

$$E_2 = -13{\cdot}6 \times \frac{Z^2}{n^2} = -13{\cdot}6 \times \frac{(1)^2}{(2)^2}$$

$$= -13{\cdot}6 \times \frac{1}{4} = -3{\cdot}4\ \text{eV}$$

Hence,

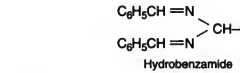
$$E_2 - E_1 = -3{\cdot}4 - (-13{\cdot}6)$$

$$= 10{\cdot}2\ \text{eV}$$

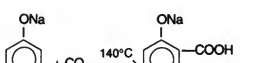
4. $C_6H_5CHO + H_2N-H \longrightarrow C_6H_5CH=N-CH-C_6H_5 + 3H_2O$

$C_6H_5CHO + H_2N-H$

Hydrobenzamide

5. 

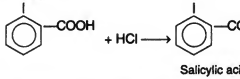
Sod-phenoxide



Salicylic acid

6. Gattermann Koch Reaction

$$:C{=}O + HCl + AlCl_3 \longrightarrow H-\overset{+}{C}{=}O + AlCl_4^-$$



7. $2C_6H_6 \longrightarrow C_6H_5-C_6H_5 + H_2$

Diphenyl

$3C_6H_6 \longrightarrow C_6H_5-C_6H_4-C_6H_5 + 2H_2$

Diphenyl benzene

8. Reducing action of ozone

$BaO_2 + O_3 \longrightarrow BaO + 2O_2$

$Ag_2O + O_3 \longrightarrow 2Ag + 2O_2$

$Na_2O_2 + H_2O + O_3 \longrightarrow 2NaOH + 2O_2$

$K_4[Fe(CN)_6]$ cannot be reduced by ozone, instead, it is oxidised as :

$2K_4[Fe(CN)_6] + H_2O + O_3 \longrightarrow 2K_3[Fe(CN)_6] + 2KOH + O_2$

9. Hypophosphorus acid is monobasic oxyacid of phosphorus

Due to P—H bonds it acts as a reducing agent.

10. $3CuO + 2NH_3 \longrightarrow 3Cu + 3H_2O + N_2$

Therefore, Cu_3N_2 is not the product.

11. The p^{K_a} is a measure of strength of an acid. If acid ionizes almost completely then K_a will be large and p^{K_a} will be the small. With oxy acids having more than one hydrogen atoms the successive p^{K_a} values become more and more positive *i.e.*, the phosphate ions formed on successive removal of H^+ become less acidic.

$H_3PO_4 \rightleftharpoons H^+ + H_2PO_4^-$; $p^K = 2{\cdot}15$

$H_2PO_4^- \rightleftharpoons H^+ + HPO_4^{2-}$; $p^{K_a} = 7{\cdot}20$

$HPO_4^{2-} \rightleftharpoons H^+ + PO_4^{3-}$; $p^{K_a} = 12{\cdot}37$

12. $4NH_3 + 3Ca(OCl)_2 \rightarrow 2N_2 + 3CaCl_2 + 6H_2O$

Hence, N_2 is the main product of the reaction.

13. Conductivities of metals are as :

Silver	$6{\cdot}3 \times 10^5$ ohm cm^{-1}
Copper	$6{\cdot}0 \times 10^5$ ohm cm^{-1}
Sodium	$2{\cdot}4 \times 10^5$ ohm cm^{-1}
Zinc	$1{\cdot}7 \times 10^5$ ohm cm^{-1}

Hence, zinc has lowest conductivity.

14. The E^{υ} values for the changes $Fe^{3+} \rightarrow Fe$ and $Fe^{2+} \rightarrow Fe$ are both negative : hence, ΔG is positive ($\Delta G = -nFE^0$). Therefore, neither Fe^{3+} nor Fe^{2+} have any tendency to reduce to Fe.

15. Didymium is an old name but later resolved into two lanthanides, Praseodymium and neodymium. This catalyst is finely powdered mixture of two solids, which flows like a liquid and this is termed as fluidised bed. It is used in the preparation of chlorine from the oxidation of HCl.

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Numerical Correlations in Estimation of Elements and Determination of Formulae of Organic Compounds

Estimation of Elements

1. Estimation of Carbon, Hydrogen and Oxygen :

- Carbon and hydrogen are estimated by Liebig method.
- Estimation of C and H is done by combustion.
- Known weight of organic compound (*wg*) is heated with CuO in a combustion tube.
- Carbon is oxidised to CO_2 and hydrogen to H_2O.
- These are absorbed by KOH and $CaCl_2$ tubes respectively.
- Increase in weight of potash tube (*xg*) gives the weight of CO_2 while increase in $CaCl_2$ tube (*yg*) gives the weight of H_2O.

Now since the molecular mass of CO_2 = 44 and it contains 12 g of carbon.

Hence, weight of carbon in *x* g of $CO_2 = x \times \frac{12}{44}$ g.

$\therefore$ Percentage of carbon in *w* g of compound

$$= x \times \frac{12}{44} \times \frac{100}{w}$$

Thus, the general formula for percentage of carbon is

$$\text{Wt. of } CO_2 \text{ produced} \times \frac{12}{44} \times \frac{100}{\text{wt. of compound}}$$

Similarly—

The molecular mass of H_2O is 18 which contains 2 parts by weight of hydrogen.

Hence wt. of hydrogen in *y* g of $H_2O = y \times \frac{2}{18}$ g

$\therefore$ Percentage of hydrogen in compound

$$= y \times \frac{2}{18} \times \frac{100}{w}$$

$$\text{Wt. of } H_2O \text{ produced} \times \frac{2}{18} \times \frac{100}{\text{wt. of compound}}$$

- As there is no direct method for the estimation of oxygen, its percentage can be calculated by difference.

$$\text{Percentage of oxygen} = 100 - (\% \text{ of C} + \% \text{ of H})$$

Example—0·4 g of an organic compound containing carbon, hydrogen and oxygen gave on combustion 0·08 g of water and 0·39 g of carbon dioxide. Find out the percentage composition of the compound.

Solution :

Percentage of Carbon

$$= \text{Wt. of } CO_2 \times \frac{12}{44} \times \frac{100}{\text{wt. of compound}}$$

$$= 0{\cdot}39 \times \frac{12}{44} \times \frac{100}{0{\cdot}4}$$

$$= 26{\cdot}59$$

Percentage of Hydrogen

$$= \text{Wt. of } H_2O \times \frac{2}{18} \times \frac{100}{\text{wt. of compound}}$$

$$= 0{\cdot}08 \times \frac{2}{18} \times \frac{100}{0{\cdot}4} = 2{\cdot}22$$

Percentage of Oxygen

$$= 100 - (26{\cdot}59 + 2{\cdot}22) = 71{\cdot}19$$

2. Estimation of Nitrogen :

(A) Duma's Method—

- Weighed quantity of organic compound is heated in a combustion tube with cupric oxide in an atmosphere of carbon dioxide.

$$C_xH_yN_z + CuO \rightarrow x\,CO_2 + \frac{y}{2}H_2O + \frac{z}{2}N_2 + \text{oxides of N}$$

- The oxides of nitrogen formed on combustion are reduced by copper spiral which is placed in the way of nitrogen oxides,

$$2NO + 2Cu \rightarrow 2CuO + N_2;$$
$$Cu + N_2O \rightarrow CuO + N_2$$
$$2NO_2 + 4Cu \rightarrow 4CuO + N_2$$

- Nitrogen is thus measured by nitrometer, where all gases are absorbed except nitrogen.

Example—0·2 g of an organic compound gave on combustion 31·7 cm^3 of moist nitrogen measured at 14°C and 758 mm pressure. Find out the percentage of nitrogen in the compound. (Aqueous tension at 14°C is 14 mm)

Solution :

Volume of moist nitrogen at 14°C and 758 mm = 31·7 cm^3.

Converting the volume of nitrogen at N.T.P.

Aqueous tension at 14°C = 14 mm

Hence, $V_1 = 31{\cdot}7\ cm^3$ $V_2 = ?$

$P_1 = 758 - 14 = 744$ mm $P_2 = 760$ mm

$T_1 = 14 + 273 = 287$ K $T_2 = 273$ K

Applying gas equation, the volume of dry nitrogen at NTP

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$V_2 = \frac{P_1 \times V_1}{T_1} \times \frac{T_2}{P_2}$$

$$= \frac{744 \times 31{\cdot}7 \times 273}{287 \times 760}$$

$$= 29{\cdot}519 \text{ cm}^3$$

$\because$ Wt. of 22400 cm^3 of N_2 at NTP

$$= 28 \text{ g}$$

$\therefore$ Wt. of 29·519 cm^3 of N_2 at NTP

$$= \frac{28}{22400} \times 29{\cdot}519 \text{ g}$$

$\frac{28}{22400} \times 29{\cdot}519$ g of N is present in 0·2 g of compound

$\therefore$ Percentage of nitrogen

$$= \frac{28 \times 29{\cdot}519 \times 100}{22400 \times 0{\cdot}20}$$

$$= 18{\cdot}45$$

$$\text{Percentage of N} = \frac{\text{Wt. of nitrogen} \times 100}{\text{Wt. of compound}}$$

$$\text{Percentage of N} = \frac{\text{Volume of } N_2 \text{ at NTP} \times 28 \times 100}{22400 \times \text{wt. of compound}}$$

(B) Kjeldahl's Method —

- Known weight of compound is heated with excess of conc. H_2SO_4 and some potassium sulphate and copper sulphate.
- Copper sulphate acts as catalyst and potassium sulphate raises the boiling point of H_2SO_4.
- Whole nitrogen in compound is quantitatively converted into $(NH_4)_2SO_4$.
- The solution containing $(NH_4)_2SO_4$ is heated with caustic soda which results in evolution of ammonia.

  Compound containing nitrogen + $H_2SO_4 \rightarrow (NH_4)_2SO_4$

  $(NH_4)_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2NH_3 + 2H_2O$
- The ammonia evolved is passed into a known volume of standard solution of sulphuric acid. The excess H_2SO_4 is then titrated against standard solution of NaOH.

  Suppose,
  - Weight of organic compound = w g
  - Volume of N acid taken in flask = V_1 cm^3
  - Volume of acid left after passing NH_3 = V_2 cm^3
  - Volume of acid neutralised by NH_3

$$= V_1 - V_2$$

$$= V \text{ cm}^3$$

Hence,

$$V \text{ cm}^3 \text{ of N acid} \equiv V \text{ cm}^3 \text{ of N } NH_3$$

$\because$ 1000 cm^3 of N-NH_3 contains

$$= 17 \text{ g of } NH_3$$

$$= 14 \text{ g of N}$$

$\therefore$ V cm^3 of N-NH_3 contains $= \frac{14 \times V}{1000}$ g of N

Hence, w g compound contains $= \frac{14 \times V}{1000}$ g of N

$\therefore$ 100 g compound contains $= \frac{14 \times V \times 100}{1000 \times w}$ g of N

$$\therefore \text{ Percentage of Nitrogen} = \frac{1{\cdot}4 \times N \times V}{w}$$

Example—0·2 g compound on being digested with conc. H_2SO_4 followed by distillation with NaOH, evolved ammonia which was passed in 50 cm^3 of $\frac{N}{10}$ H_2SO_4. The excess of acid was titrated with $\frac{N}{5}$ NaOH. 10 cm^3 of NaOH were required for titration. Find out the percentage of nitrogen in the compound.

Solution :

Weight of organic compound

$$= 0{\cdot}2 \text{ g}$$

Volume of acid taken = 50 cm^3 of N/10 H_2SO_4

$$= 25 \text{ cm}^3 \text{ of N/5 } H_2SO_4$$

Volume of NaOH needed to neutralise excess of H_2SO_4

$$= 10 \text{ cm}^3 \text{ of N/5 NaOH}$$

10 cm^3 of N/5 NaOH $\equiv$ 10 cm^3 of N/5 H_2SO_4

$\therefore$ Volume of N/5 H_2SO_4 neutralised by NH_3

$$= 25 - 10$$

$$= 15 \text{ cm}^3$$

Hence, percentage of nitrogen

$$= \frac{1{\cdot}4 \times N \times V}{w}$$

$$= 1{\cdot}4 \times \frac{1}{5} \times \frac{15}{0{\cdot}20}$$

$$= 21$$

$$= 21\% \text{ N}$$

Estimation of Halogens ;

Carius method—In this method a known weight of organic compound is placed in a jena glass tube containing conc. HNO_3 and a few crystals of $AgNO_3$. Tube is sealed and heated at 200°C for 6 to 7 hours in carius furnace. The halogen present in compound is quantitatively changed into silver halide which is estimated **gravimetrically**.

Suppose, x g silver halide is formed from w g of compound, then

$$\text{Percentage of Cl} = \frac{35{\cdot}5}{143{\cdot}5} \times \frac{x \times 100}{w}$$

$$\text{Percentage of Br} = \frac{80}{188} \times \frac{x \times 100}{w}$$

$$\text{Percentage of I} = \frac{127}{235} \times \frac{x \times 100}{w}$$

In general percentage of halogen

$$= \frac{\text{At. wt. of halogen}}{\text{Mol. wt. of silver halide}} \times \frac{\text{wt. of silver halide} \times 100}{\text{wt. of compound}}$$

Example—0·25 g of an organic compound when heated with HNO_3 and $AgNO_3$ in a carius tube, gave 0·3500 g of silver chloride. Find out the percentage of chlorine in the compound.

Solution :

$$\text{Percentage of chlorine} = \frac{35{\cdot}5}{143{\cdot}5} \times \frac{0{\cdot}3500}{0{\cdot}25} \times 100$$

$$= 34{\cdot}64$$

Note—In addition to carius method, halogens are also estimated by **Piria** and **Schiff's method** and **Stepanov's method.**

Estimation of Sulphur :

Carius method—A known weight of the compound is heated with fuming HNO_3 in a carius tube. Sulphur of the compound is oxidised to sulphuric acid. After cooling, the contents are transferred into a beaker. Some excess of $BaCl_2$ is added to get the precipitate of $BaSO_4$. Precipitate is filtered, washed and weighed. The percentage of sulphur is calculated as

Percentage of sulphur

$$= \frac{\text{At. wt. of S} \times \text{wt. of } BaSO_4 \times 100}{\text{Mol. wt. of } BaSO_4 \times \text{wt. of compound}}$$

$$= \frac{32}{233} \times \frac{\text{wt. of } BaSO_4 \times 100}{\text{wt. of compound}}$$

Note—In addition to carius method, sulphur can also be estimated by Messenger's method and Asboth's method.

Example—0·35 g of an organic compound containing sulphur was heated in a carius tube and H_2SO_4 formed was precipitated as $BaSO_4$ with $BaCl_2$. The weight of $BaSO_4$ was found to be 0·35 g. Find out the percentage of sulphur in the compound.

Solution :

$$\text{Percentage of sulphur} = \frac{32}{233} \times \frac{0{\cdot}35 \times 100}{0{\cdot}35}$$

$$= 13{\cdot}73$$

Determination of Formula of Organic Compound

1. Empirical Formula :

The empirical formula of an organic compound represents the simplest ratio of atoms of different atoms present in the molecule of the compound.

The empirical formula of a compound is worked out from the percentage of various elements present in the compound.

Example—0·2 g of an organic compound gave on combustion 75 cm^3 of nitrogen at NTP. In second experiment same weight of compound gave 0·145 g of CO_2 and 0·12 g of water. Find out the empirical formula of the compound.

Solution :

$$\text{Percentage of carbon} = 0{\cdot}145 \times \frac{12}{44} \times \frac{100}{0{\cdot}2}$$

$$= 19{\cdot}77$$

$$\text{Percentage of hydrogen} = 0{\cdot}12 \times \frac{2}{18} \times \frac{100}{0{\cdot}2}$$

$$= 6{\cdot}66$$

Percentage of nitrogen (Duma's method)

$$= 75 \times \frac{28}{22400} \times \frac{100}{0{\cdot}2}$$

$$= 46{\cdot}87$$

Percentage of oxygen (by difference)

$$= 100 - (19{\cdot}77 + 6{\cdot}66 + 46{\cdot}87)$$

$$= 100 - 73{\cdot}30 = 26{\cdot}70$$

Element	Percentage of Element	At. wt. of Element	Relative number of Atoms	Simplest Ratio
Carbon	19·77	12	$\frac{19{\cdot}77}{12} = 1{\cdot}65$	$\frac{1{\cdot}65}{1{\cdot}65} = 1$
Hydrogen	6·66	1	$\frac{6{\cdot}66}{1} = 6{\cdot}66$	$\frac{6{\cdot}66}{1{\cdot}65} = 4$
Nitrogen	46·87	14	$\frac{46{\cdot}87}{14} = 3{\cdot}34$	$\frac{3{\cdot}34}{1{\cdot}65} = 2$
Oxygen	26·70	16	$\frac{26{\cdot}70}{16} = 1{\cdot}66$	$\frac{1{\cdot}66}{1{\cdot}65} = 1$

The ratio of different atoms of different elements

C : H : N : O

1 : 4 : 2 : 1

Hence, empirical formula of compound is CH_4N_2O.

Example—0·40 g of an organic compound gave on combustion 0·80 g of CO_2 and 0·30 g of H_2O. 0·24 g of same compound was treated according to Kjeldahl's method. The NH_3 formed was absorbed in 50 cm^3 of 0·25N H_2SO_4. The excess of H_2SO_4 required 75 cm^3 of 0·1N NaOH for complete neutralisation. Find out the empirical formula of the compound.

Solution :

$$\text{Percentage of carbon} = 0{\cdot}80 \times \frac{12}{44} \times \frac{100}{0{\cdot}40}$$

$$= 47{\cdot}43$$

$$\text{Percentage of hydrogen} = 0{\cdot}30 \times \frac{2}{18} \times \frac{100}{0{\cdot}40} = 8{\cdot}3$$

Percentage of Nitrogen—

Weight of compound = 0·24 g

Total acid taken = 50 cm^3 of 0·25 N H_2SO_4

75 cm^3 of 0·1 N NaOH ≡ 75 cm^3 of 0·1 N H_2SO_4

$$= 7{\cdot}5 \text{ cm}^3 \text{ of N } H_2SO_4$$

$$= 30 \text{ cm}^3 \text{ of } 0{\cdot}25 \text{ N } H_2SO_4$$

∴ Acid neutralized by ammonia

$$= (50 - 30)$$

$$= 20 \text{ cm}^3 \text{ of } 0{\cdot}25 \text{ N } H_2SO_4$$

$$\text{Percentage of nitrogen} = \frac{1{\cdot}4\,NV}{w}$$

$$= \frac{1.4 \times 0.25 \times 20}{0.24} = 29$$

Percentage of oxygen (by difference)

$= 100 - (47.43 + 8.30 + 29.0)$

$= 100 - 84.73 = 15.27$

Element	Percentage of Element	At. wt. of Element	Relative number of Atoms	Simplest Ratio
Carbon	47.43	12	$\frac{47.43}{12} \approx 4$	4
Hydrogen	8.30	1	$\frac{8.30}{1} \approx 8$	8
Nitrogen	29.00	14	$\frac{29}{14} \approx 4$	2
Oxygen	15.27	16	$\frac{15.27}{16} \approx 4$	1

The ratio of atoms of different elements is

C : H : N : O

4 : 8 : 2 : 1

Thus empirical formula of organic compound is

$C_4H_8N_2O$

2. Molecular Formula:

Molecular formula of a compound expresses the actual number of atoms of each element present in the molecule of the compound.

For determination of molecular formula, the molecular weight of compound should be known. Following points have to be taken into account while determining the molecular formula of the compound :

(i) Empirical formula weight is calculated by adding up atomic weights of various atoms present in the empirical formula of the compound.

(ii) Molecular wt. is then divided by empirical formula wt. Let the quotient be '*n*'.

(iii) Multiply the empirical formula by the quotient '*n*' to get the molecular formula.

Molecular formula = $n \times$ Empirical formula

Where $n = \frac{\text{Molecular weight}}{\text{Empirical formula weight}}$

Example—A volatile organic compound contained 10 per cent carbon, 0·84 percent hydrogen and 89·12 per cent chlorine. In Victor Meyer's method 0·6 g of this compound displaced 122 cm^3 of air at NTP. Find out the molecular formula of the compound.

Solution :

(i) Calculation of empirical formula

Element	Percentage of Element	At. wt. of Element	Relative number of Atoms	Simplest Ratio
Carbon	10	12	$\frac{10}{12} = 0.83$	$\frac{0.83}{0.83} = 1$
Hydrogen	0.84	1	$\frac{0.84}{1} = 0.84$	$\frac{0.84}{0.83} = 1$
Chlorine	89.12	35.5	$\frac{89.12}{35.5} = 2.55$	$\frac{2.55}{0.83} = 3$

The empirical formula of the compound is $CHCl_3$.

The empirical formula weight of the compound.

C H 3Cl

$12 + 1 + 3 \times 35.5 = 119.5$

(ii) Determination of molecular weight

$\because$ 112 cm^3 of vapour of compound at NTP weighs

$= 0.6$ g

$\therefore$ 22400 cm^3 of vapour of compound at NTP weighs

$$= \frac{0.6 \times 22400}{112} \text{ g}$$

$= 120$ g

Hence, molecular weight of the compound is 120

(iii) Determination of molecular formula

$$n = \frac{\text{Molecular weight}}{\text{Empirical formula weight}}$$

$$= \frac{120}{119.5} \approx 1$$

Hence, molecular formula

= Empirical formula $\times n$

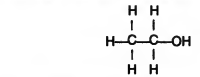
$= CHCl_3 \times 1$

$= CHCl_3$

Molecular formula of compound is $CHCl_3$

Structural Formula :

The structural formula of a compound shows the linking pattern of various atoms in a molecule. This is determined if the molecular formula and characteristic properties of compound are known. For example a compound with molecular formula C_2H_6O shows the characteristics of alcohol, then its structure will be as



As the determination of structural formula is the final stage of molecular analysis, it needs a detailed spectroscopic investigation and is a subject of separate study.

Determination of Molecular formula of Gaseous Hydrocarbons :

The molecular formula of hydrocarbons can be determined even without knowing the percentage composition of the hydrocarbon.

- A known volume of pure hydrocarbon is mixed with excess but known volume of oxygen and exploded in a **eudiometer** tube.
- Carbon and hydrogen form carbon dioxide and water respectively.
- After cooling, the volume of gaseous mixture is noted which includes CO_2 and unreacted O_2.
- Decrease in volume after cooling is the volume of water produced.
- The volume of CO_2 is determined by decrease which takes place by passing the cold gas in KOH solution.

- The remaining gas is unreacted O_2 which is absorbed in alkaline pyrogallol.
- The volume of oxygen used is then calculated by subtracting the volume of unused O_2 from total volume of O_2 taken.

The molecular formula is calculated with the help of following combustion equation of hydrocarbon.

$$C_xH_y + \left(x + \frac{y}{4}\right)O_2 \rightarrow x\,CO_2 + \frac{y}{2} + H_2O$$

Example—A mixture of 10 cm^3 of hydrocarbon and 100 cm^3 of oxygen was exploded. On cooling, the volume was reduced to 95 cm^3. On passing remaining mixture in the KOH solution, the volume was further reduced to 75 cm^3. All volumes were measured under the similar conditions of temperature and pressure. Find out the molecular formula of the hydrocarbon.

Solution :

- Volume of hydrocarbon = 10 cm^3
- Volume of oxygen mixed = 100 cm^3
- Volume after cooling *i.e.*, the volume of CO_2 + unused O_2 = 95 cm^3.
- Volume of unused O_2 = 75 cm^3
- Volume of used O_2 = 100 – 75 = 25 cm^3
- Volume of CO_2 *i.e.*, reduction in volume after passing through KOH = 95 – 75 = 20 cm^3

Suppose, the formula of hydrocarbon is C_xH_y, its combustion will take place as

$$C_xH_y + \left(x + \frac{y}{4}\right)O_2 \rightarrow x\,CO_2 + \frac{y}{2}\,H_2O$$

$$10\ cm^3 \quad 10\left(x + \frac{y}{4}\right)cm^3 \rightarrow 10x\ cm^3$$

Hence, 10 cm^3 of hydrocarbon will need $10\left(x + \frac{y}{4}\right)$ cm^3 of O_2 for its complete combustion and $10x$ cm^3 of CO_2 will be produced.

Volume of CO_2 produced = $20 = 10\,x\ cm^3$

$$x = \frac{20}{10} = 2$$

Volume of oxygen used = $25 = 10\left(x + \frac{y}{4}\right)\ cm^3$

Substituting the value of x in above equation

$$25 = 10\left(2 + \frac{y}{4}\right)$$

$$25 = 20 + \frac{5y}{2}$$

$$25 - 20 = \frac{5y}{2}$$

$$5 = \frac{5y}{2}$$

$$5y = 10$$

$$y = \frac{10}{5} = 2$$

Now on substituting the values of x and y in the formula C_xH_y the molecular formula of hydrocarbon comes out to be C_2H_2.

Example—357 cm^3 of air is needed for complete combustion of 15 cm^3 of a gaseous hydrocarbon. The air contains only 21 per cent of oxygen by volume. After the combustion, the volume of gaseous mixture was found to be 327 cm^3. Find out the molecular formula of hydrocarbon.

Solution :

Volume of hydrocarbon = 15 cm^3

Volume of oxygen used—

$\because$ 100 cm^3 of air contains 21 cm^3 of O_2

$\therefore$ 357 cm^3 air contains $= \frac{21 \times 357}{100}$

$= 75\ cm^3$ of O_2

Volume of residual air = 357 – 75

= 282 cm^3

Volume of CO_2 produced = 327 – 282 = 45 cm^3

Suppose the molecular formula of hydrocarbon is C_xH_y. Therefore, according to combustion equation.

$$C_xH_y + \left(x + \frac{y}{4}\right)O_2 \rightarrow x\,CO_2 + \frac{y}{2}H_2O$$

$$15\ cm^3 \quad 15\left(x + \frac{y}{4}\right)cm^3 \rightarrow 15x\ cm^3$$

We know that volume of CO_2 produced is 45 cm^3

$\therefore$ $15x = 45$

$$x = \frac{45}{15} = 3$$

$$x = 3$$

Now substituting the value of x in the equation

$$15\left(x + \frac{y}{4}\right) = 75\ cm^3$$

$$15\left(3 + \frac{y}{4}\right) = 75$$

$$45 + \frac{15y}{4} = 75$$

$$\frac{15y}{4} = 75 - 45$$

$$\frac{15y}{4} = 30$$

$$15y = 120$$

$$y = \frac{120}{15} = 8$$

$$y = 8$$

Thus, the molecular formula of hydrocarbon is C_3H_8.

Example—15 cm^3 of a hydrocarbon required 45 cm^3 of oxygen for complete combustion. As a result of combustion 30 cm^3 of carbon dioxide were formed. Find out the molecular formula of hydrocarbon.

Solution : Combustion equation

$$C_xH_y + \left(x + \frac{y}{4}\right)O_2 \rightarrow x\,CO_2 + \frac{y}{2}H_2O$$

$$15\ cm^3 \quad 15\left(x + \frac{y}{4}\right)cm^3 \rightarrow 15x\ cm^3$$

Now $15x = 30$

$$x = \frac{30}{15} = 2$$

$$x = 2$$

Again, $15\left(x + \frac{y}{4}\right) = 45$

$$15x + \frac{15y}{4} = 45$$

Substituting the value of x

$$15 \times 2 + \frac{15y}{4} = 45$$

$$\frac{15y}{4} = 45 - 30 = 15$$

$$15y = 15 \times 4$$

$$y = \frac{15 \times 4}{15} = 4$$

Hence, molecular formula of hydrocarbon is C_2H_4.

Example—An olefinic hydrocarbon was burnt with excess of oxygen. On cooling a reduction of 16 cm^3 took place. On adding KOH further reduction of 16 cm^3 took place. Find out the molecular formula of hydrocarbon.

Solution :

Here volume of hydrocarbon and oxygen is not given. We know the general formula of olefin is C_nH_{2n}

The combustion reaction will take place as—

$$C_nH_{2n} + \left(\frac{3n}{2}\right)O_2 \longrightarrow nCO_2 + nH_2O$$

$$1V \qquad \left(\frac{3n}{2}\right)V \qquad nV$$

Given,

Volume of CO_2 formed = 16 cm^3

Volume of H_2O vapour formed = 16 cm^3

Therefore, $nV = 16$

$$V = \frac{16}{n}$$

$\frac{16}{n}$ cm^3 will be the volume of hydrocarbon.

Therefore,

$$C_nH_{2n} + \left(\frac{3n}{2}\right)O_2 \longrightarrow nCO_2 + nH_2O$$

$$\frac{16}{n}\ cm^3 \quad \frac{16}{n}\left(\frac{3n}{2}\right)\ cm^3 \longrightarrow 16\ cm^3$$

Reduction in volume after cooling

= Volume before combustion – Volume of CO_2

$$16 = \left[\frac{16}{n} + \frac{16}{n}\left(\frac{3n}{2}\right)\right] - 16$$

$$16 = \left[\frac{16}{n} + 24\right] - 16$$

$$16 = \frac{16}{n} + 24 - 16$$

$$16 = \frac{16}{n} + 8$$

$$\frac{16}{n} = 16 - 8$$

$$\frac{16}{n} = 8$$

$$n = 2$$

Hence, the molecular formula of hydrocarbon is C_2H_4.

Points to Remember

- When volume of hydrocarbon and the volume of oxygen needed for its complete combustion are known and name of hydrocarbon is asked, apply following formulae :

(1) $\frac{\text{Volume of hydrocarbon}}{\text{Volume of oxygen}} = \frac{2}{3n+1}$

(n = no. of C atoms)

This relation is for saturated hydrocarbons

(2) $\frac{\text{Volume of hydrocarbon}}{\text{Volume of oxygen}} = \frac{2}{3n}$

This is for alkenes.

(3) $\frac{\text{Volume of hydrocarbon}}{\text{Volume of oxygen}} = \frac{2}{3n-1}$

This relation is applied for alkynes.

Knowing the value of 'n', the name of hydrocarbon can be given.

- Equation for the combustion of hydrocarbons

(1) $C_xH_y + \left(x + \frac{y}{4}\right)O_2 \rightarrow xCO_2 + \frac{y}{2}H_2O$.

(2) $C_nH_{2n} + \left(\frac{3n}{2}\right)O_2 \rightarrow n\,CO_2 + n\,H_2O$

- Equation for combustion of compounds containing oxygen

$$C_xH_yO_z + \left(\frac{x+y}{4} - \frac{z}{2}\right)O_2 \rightarrow x\,CO_2 + \frac{y}{2}H_2O$$

- Percentage of nitrogen =

$$\frac{\text{Volume of } N_2 \text{ at NTP} \times 28 \times 100}{22400 \times \text{wt. of organic compound}}$$

OBJECTIVE QUESTIONS

1. In Kjeldahl's method nitrogen present in organic compound is estimated as—
   (A) $(CN)_2$ (B) NH_3
   (C) NO_2 (D) All of these
2. Carbon and hydrogen present in an organic compound are estimated quantitatively by—
   (A) Carius method
   (B) Liebig's method
   (C) Messenger's method
   (D) Asboth's method
3. In Duma's method for estimating nitrogen in an organic compound, the gas which is finally collected is—
   (A) NH_3
   (B) N_2
   (C) NO_2
   (D) None of these
4. In Kjeldahl's method, employed for quantitative estimation of nitrogen in an organic compound, copper sulphate acts as–
   (A) Reducing agent
   (B) Oxidising agent
   (C) Catalyst
   (D) None of these
5. Which of the following expressions is correct for determining the

percentage of nitrogen by Kjeldahl's method ?

(A) $\frac{1{\cdot}4 \times N \times V}{w}$

(B) $\frac{1{\cdot}4 \times N_2 \times V}{10 \times w}$.

(C) $\frac{14 \times N \times V}{w}$

(D) $\frac{1{\cdot}4 \times N \times w}{v}$

6. In a carius tube $ClCH_2COOH$ is heated with fuming nitric acid and a few crystals of $AgNO_3$, a white precipitate is obtained. The precipitate is of—
(A) $AgNO_3$
(B) Ag_2SO_4
(C) AgCl
(D) $ClCH_2COOAg$

7. An organic compound contains 80 per cent carbon and 20 per cent hydrogen, the compound is—
(A) C_6H_6 (B) C_2H_5OH
(C) C_2H_6 (D) C_2H_4

8. Number of moles of water formed by complete combustion of C_3H_6 is—
(A) 2
(B) 3
(C) 4
(D) None of these

9. The number of moles of oxygen required for complete combustion of one mole of a hydrocarbon C_xH_y, is—

(A) $\left(x+\frac{y}{4}\right)$ (B) $\left(y+\frac{x}{4}\right)$

(C) $x\left(\frac{y}{4}\right)$ (D) $y\left(\frac{x}{4}\right)$

10. When one mole of ethylene is completely burnt in excess of oxygen, the volume of CO_2 produced at NTP will be—
(A) 22·4 litre (B) 44·8 litre
(C) 11·2 litre (D) 2·24 litre

11. A g of an organic compound on combustion gives B g of carbon dioxide. The percentage of carbon in the compound is—

(A) $\frac{12}{44} \times \frac{A}{B} \times 100$

(B) $\frac{44}{12} \times \frac{A}{B} \times 100$

(C) $\frac{12}{44} \times \frac{B}{A} \times 100$

(D) $\frac{44}{12} \times \frac{B}{A} \times 100$

12. An organic compound contains H, C and O. 0·24 g of this compound on combustion gives 0·22 g of CO_2. The percentage of H in the compound is 1·66. What is the percentage of oxygen in the compound ?
(A) 25 (B) 73·34
(C) 36·6 (D) 75

13. 10 cm^3 of a hydrocarbon on explosion with O_2 gives 30 cm^3 of carbon dioxide. If the formula of hydrocarbon is C_xH_y, the value of x will be—
(A) 1 (B) 2
(C) 3 (D) 4

14. The volume of the oxygen required for complete combustion of 10 cm^3 of C_xH_y will be—

(A) $10\left(\frac{y}{4}\right)$ cm^3

(B) $10\left(\frac{x+y}{4}\right)$ cm^3

(C) $10\,x\,cm^3$

(D) $10\,x+\frac{y}{4}cm^3$

15. The combustion reaction of carbon monoxide is as—

$$2CO + O_2 \rightarrow 2CO_2$$
$$x\ cm^3 \quad x/2\ cm^3 \quad x\ cm^3$$

The contraction in volume due to burning of carbon monoxide will be—

(A) $x-\frac{x}{2}\times x$ (B) $x+\frac{x}{2}-x$

(C) $\frac{2}{x}cm^3$ (D) $\frac{x}{3}cm^3$

16. Volume of oxygen required for complete combustion of one litre of methane at STP, will be—
(A) 0·5 litre (B) 1 litre
(C) 2·0 litre (D) 1·5 litre

17. 10 cm^3 of a gaseous hydrocarbon is burnt completely in 80 cm^3 of O_2 at NTP. The residual gas occupied 70 cm^3. This volume became 50 cm^3 on treatment of KOH solution. The empirical formula of the hydrocarbon is—
(A) C_2H_2 (B) C_2H_6
(C) C_2H_4 (D) CH_2

18. The volume of air (containing 21% of O_2 by volume) required to completely burn 5 litre of methane at STP, will be—
(A) 5 litre (B) 10 litre
(C) 47·62 litre (D) 62·47 litre

19. 25 cm^3 of CH_4 were mixed with 75 cm^3 of O_2 and the mixture was exploded. The product was treated with NaOH. What will be the volume of residual gas if temperature and pressure are constant ?
(A) 50 cm^3 (B) 25 cm^3
(C) 75 cm^3 (D) 100 cm^3

20. 25 cm^3 of a mixture of nitrogen and nitric oxide is passed over ignited copper and gaseous product is collected and found to occupy 20 cm^3. The percentage composition of the mixture will be—
(A) N_2 = 60%, NO = 40%
(B) N_2 = 40%; NO = 60%
(C) N_2 = 70%; NO = 30%
(D) N_2 = 30%; NO = 70%

ANSWERS

1. (B) 2. (B) 3. (B) 4. (C) 5. (A)
6. (C) 7. (C) 8. (B) 9. (A) 10. (B)
11. (C) 12. (B) 13. (C) 14. (B) 15. (B)
16. (C) 17. (C) 18. (C) 19. (B) 20. (A)

SEX DETERMINATION AND SEX-LINKED CHARACTERS

In mammals the sexes have equal number of autosomes but males have one X and one Y chromosome and females have two X chromosomes. The sex with two different sex chromosomes is the **heterogametic sex**, and the other, with two of the same sex chromosomes is the **homogametic sex**. In all mammals, the male is the heterogametic sex and female is homogametic sex. In birds, moths and butterflies, the female is the heterogametic sex.

For a long time, scientists have been engaged in discovering the factor or factors which determine the sex of an individual progeny in unisexual species. Just after the discovery of Mendelism, it was discovered that sex of an individual is determined by its chromosomal pattern and it is inherited according to simple Mendelian principles. In 1891, Henking had detected a possible 'sex chromosome' in the sperms of a plant bug and had named it 'X' chromosome. Ultimately, McLung (1902) descisively proved that sex is transmitted by definite sex chromosomes and propounded the 'Chromosomal Theory of Sex Determination'.

Human Karyotype :

Using modern techniques Tijo and Levan (1956) demonstrated that human Karyotype consists only 23 pairs (46) of chromosomes. Of these 23 pairs, 22 pairs are of homologous chromosomes, and these are called **autosomes**. In women, chromosomes of the 23rd pair are also homologous. These are elongated, rod shaped and designated 'X' chromosome. In men, however, the chromosomes of 23rd pair are dissimilar (non-homologous) and called **heterosomes** or **allosomes**. One of these is an 'X' chromosome, homologous to the X-chromosomes of women but its mate is relatively very small and subspherical. This latter chromosome is designated 'Y' chromosome. Thus the karyotype of men and women can be respectively as 44A + XY (or 2A + XY) and 44A + XX (or 2A + XX).

It is obvious that 'Y' chromosome in 23rd pair in men is responsible for all differences between men and women. It is, thus the **male chromosome** transmitting maleness. Thus the chromosomes of 23rd pair in humans are the sex chromosomes.

Sex Determination :

Sex is the most obvious difference in the phenotype between the individuals of many species. In most animals, the sex is genetically determined and nearly 50% individuals are male and 50% female. There are 4 main genetic mechanism of sex determination. Environment determines sex in some cases.

(1) XX-XY Type— The sex is determined in mammals, including human beings, and certain insects, such as fruitfly, in the same manner. In both, the female has similar sex chromosomes, *i.e.*, XX and the male has dissimilar sex chromosomes, *i.e.*, XY. Thus, in humans, the female is homozygous and male is heterozygous for the sex chromosomes. During maturation, the sex chromosomes segregate freely like the autosomes, so that an ovum receives an X-chromosome and a sperm gets either an X-chromosome or a Y-chromosome. Thus, the eggs are all alike, each with X-chromosome and the sperms are of two types—with X or with Y chromosome. The female is said to be **homogametic** and the male **heterogametic**. This condition is called **male digametry**. The Y-containing sperms and X-containing sperms are called respectively **androsperms** and **gynosperms**. The two are produced in equal proportions. The sex is determined at the time of fertilization by the kind of sperm that fuses with the ovum. The egg with X- chromosome fertilized by a sperm with X-chromosome will become a zygote with XX sex chromosomes. This zygote will develop into a female. The egg having X-chromosome fertilized by a sperm having Y-chromosome will become a zygote with XY sex chromosomes. This zygote will develop into a male.

Human beings have 46 chromosomes. These are distinguishable into 1 pair of sex chromosomes and 22 pairs of homologous autosomes. During maturation, the sex chromosomes segregate freely like autosomes. With the result, the ovum contains 22 autosomes and an X-chromosome, whereas a sperm contains 22 autosomes and either an X or a Y-chromosomes. Thus, the sperm of father decides the sex of offspring.

SRY Gene

In 1991, Robin Lovell-Badge and Peter Goodfellow and their colleagues in England isolated a gene called **sex-determining region Y(SRY)**, which, when injected into XX mice, caused them to develop as males. It is believed that embryos develop ovaries unless the SRY gene switches the developmental process to one that leads to testes formation. The SRY protein activates a gene on chromosome 19 that encodes a protein called Mullerian-inhibiting substance. This protein destroys the rudimentary female structures.

(2) XX-XO Type—This mechanism operates in certain insects such as cockroaches, grasshoppers and bugs. The female has two homomorphic sex chromosomes XX and is **homogametic**. It produces similar eggs, each with X-chromosome. The male has one chromosome only and is heterogametic. It produces 2 types of sperms—gynosperms with X-chromosome and androsperms with X-chromosome. Fertilization of an egg by X bearing sperm yields female offspring and by no X-chromosome sperm yields male offspring. Thus the sex is

determined at the time of fertilization as in above XX-XY type.

(3) ZW-ZZ Type—This mechanism operates in certain insects (butterflies and moths) and in vertebrates (fishes, reptiles and birds). The male has two homomorphic sex chromosomes (ZZ) and is homogametic, and the female has two heteromorphic sex chromosomes (ZW) and is heterogametic. There are thus two types of eggs—with Z and with W and only one type of sperms, *i.e.*, each with Z. Fertilization of an egg with Z-chromosome by a sperm with Z-chromosome gives a zygote with ZZ chromosomes. This zygote develops into a male, Fertilization of an egg with W-chromosome by a sperm with Z-chromosome yields a zygote with ZW chromosomes. This zygote produces a female.

(4) Haploid-Diploid Mechanism of Sex Determination—Hymenopterous insects, such as bees, wasps, sawflies and ants show a unique phenomenon in which an unfertilized egg develops into a male and a fertilized egg develops into a female. Therefore the female is diploid (2N) and the male is haploid (N). Eggs are formed by meiosis and sperms by mitosis. Fertilization restores the diploid number of chromosomes in the zygote which gives rise to the female. If the egg is not fertilized, it will still develop but into a male. Thus, the sex is determined by the number of chromosomes.

In honeybee, the quality of food determines whether a diploid larva will become a fertile queen or a sterile worker female. A larva fed on royal jelly, a secretion from the mouth of nursing workers, grows into a queen, whereas a larva fed on pollen and nectar grows into a worker bee. Thus, the kind of nutrition determines fertility or sterility of the bee but it does not alter the genetically determined sex.

Environmental Determination of Sex :

In some animals, such as ***Bonellia***, there is environmental determination of sex. The swimming larva has no sex. If it settles down alone, it develops into a large female. If it lands on an existing female, a chemical from the female causes the larva to develop into a tiny male.

Sex-Linked Characters :

Sexual dimorphism in man is complex and involves a large number of hereditary characteristics, both sexual and non-sexual (somatic). Genes of the sexual characteristics are located in sex chromosomes. Genes of most nonsex characteristics, including those of sexual dimorphism, are located on autosomes. However, genes of some nonsex characteristics are located in sex chromosomes also. These characteristics are called **'sex-linked traits'** because their inheritance is **sex-linked**.

Although X and Y chromosomes are very different (non-homologous) from each other in size, shape and structure, yet the fact that pairing or synapsis of these two occurs during meiosis, just as in the case of autosomes, indicates that there are some homologous **'pairing segments'** also in these chromosomes. Remaining parts of X and Y chromosomes are definitely non-homologous or **'differential segments'**. Genes of sex-linked characteristics occur in both 'pairing' and 'differential' segments of X and Y chromosomes. The nonsex sex-linked characteristics are, therefore, divisible into the following categories—

(1) X-linked—These genes are located in the 'differential' segments of X chromosomes. Obviously, alleles of these genes never occur in Y-chromosomes. Sons can, therefore, receive these genes only from their mothers, whereas daughters can receive these from both parents. Since the major part of X-chromosome is 'differential' or non-homologous to Y-chromosomes and Y-chromosomes are very small, it follows that genes of most of the sex-linked characteristics are located in X-chromosomes. That is why, sex-linkage usually refers to X-linked characteristics.

(2) Y-linked—These genes are located in the 'differential' segments of Y-chromosome. These genes naturally occur singly and never in allelic pairs. Obviously, these genes are transmitted only by fathers and only to their sons. Such genes are called **holandric genes**. Their inheritance is called **holandric inheritance**. Since Y-chromosomes are very small, very few holandric characteristics have been detected and these too are still not fully confirmed. One of such characteristics is **hypertrichosis** expressed as a very rich growth of hairs upon ear pinnae.

(3) XY-linked—These genes are located as alleles in 'pairing segments' of X and Y-chromosomes. These characteristics are called **incompletely sex-linked. Total colourblindness, nephritis** (a kidney disease) and some other similar diseases are XY-linked.

Sex-linked recessive inheritance :

Any gene on the X-chromosome of a male mammal is expressed in his phenotype because he lacks a second allele for that gene which would mask its expression. An allele on an X-chromosome in a female may or may not be expressed, depending upon whether it is dominant or recessive and on the nature of the allele on the second X-chromosome. The male **hemizygous** for sex-linked traits because he has half the number of genes the female has.

A male always inherits his Y-chromosome from his father and his X-chromosome from the mother. A female inherits one X-chromosome from each parent. If a mother is heterozygous for a particular sex-linked gene, her son has a 50% chance of inheriting either allele from her. Sex-linked genes are, therefore, passed from mother to son. Because a male, does not receive an X-chromosome from his father (he inherits the Y-chromosome from his father), a father does not pass a sex-linked trait to his son. **Punnett squares are used to depict transmission of sex-linked traits.**

Haemophilia-A is a sex-linked recessive disorder in which absence or deficiency of a protein clotting factor greatly slows blood clotting. A cut may take a long time to stop bleeding.

The risk that a carrier mother will pass haemophilia-A to her son is 50% because he can inherit either her normal allele or the mutant one. The risk that a daughter will inherit the haemophilia allele and be a carrier like her mother is also 50%.

A daughter can inherit a sex-linked recessive disorder or trait if her father is affected and her mother is a carrier she inherits one effected X-chromosome from each parent. Females usually do not exhibit sex-linked traits because they inherit two X-chromosomes, so the wild type allele masks the mutant.

Sex-linked dominant inheritance :

A female who inherits a dominant allele has the associated trait or illness but a male who inherits the allele is usually more severely affected. A example of a sex-linked dominant condition is **Incontinentia pigmenti**. The names comes from the major symptoms in females who have the disorder-swirls of pigment in the skin that resemble swirls of paint or marble cake. Males with the condition are so severely affected that they die in the uterus. Women with the disorder thus have a high rate of miscarriage.

Key Concepts

The human female is the homogametic sex, with two X-chromosomes; males, who are heterogametic, have one X and one Y-chromosome. The SRY gene on the Y-chromosome determines maleness in humans. It triggers a cascade of gene action that stimulates development of rudimentary male structures while suppressing development of female structures. Because a male is hemizygous, he expresses the genes on his X-chromosome, whereas a female only expresses recessive alleles on the X-chromosome if she is homozygous. Sex-linked recessive traits pass from carrier mothers to sons at a 50% rate. Sex linked dominant conditions are expressed in females but are more severe in males. Most sex-linked traits are inherited on the X-chromosome. The Y-chromosome contains very few genes. A few Y-linked traits are passed from father to son.

X-inactivation—Equalizing the sexes :

Female mammals have two alleles for every gene on the X-chromosome, while males have only one. A mechanism called **X-inactivation** helps balance this inequality in the number of sex-linked genes. Early in female development, one X-chromosome in each cell is inactivated. This occurs at about the third weak of development in humans. In most mammals, which X-chromosome is turned off—the one inherited from the mother or the one from the father—is a matter of chance. As a result, a female mammal expresses the paternal X-chromosome genes in some cells and the maternal genes in others. The exception is marsupials, the pouched mammals that include Kangaroos. For unknown reasons, these species always shut off the X-chromosome inherited from the father.

By studying rare human females who have only part of one X-chromosome, researchers have identified a specific part of the X-chromosome, the **X-inactivation Centre** that shuts off the chromosome. X inactivation is believed to occur one gene at a time. A few genes, however, escape inactivation and remain active. The inactivation process seems to be under the control of a gene called XIST, which has so far been identified in humans, cats, dogs, mice, cows and rabbits.

X-inactivation means that a female is a genetic mosaic of any heterozygous genes on the X-chromosome because some cells express one allele and other cells express the other allele. Heterozygosity can still offer a female protection from sex-linked disorders. If the female inherits one allele that specifies a vital enzyme, and another allele that specifies an inactive version, she will probably still be healthy because some of her cells will manufacture the enzyme. A male who has the defective allele would not survive.

X inactivation may be obvious. The brown swirls of skin colour incontinentia pigmenti patients reflect cells in the deeper skin layers where the wild type allele is shut off.

Rarely, a female who is heterozygous for a sex-linked gene expresses the associated condition. This can happen in a female carrier of haemophilia. If the X-chromosome carrying the normal allele for the clotting factor is, by chance, turned off in many of her immature blood platelet cells, her blood will take longer than normal to clot—a mild symptom of haemophilia. When a carrier of a sex-linked trait expresses the phenotype, she is called a **manifesting heterozygote**.

Barr Body

Biologists can easily observe X-inactivation in female cells. The turned-off X-chromosome absorbs a stain much more readily than the active chromosome. In the nucleus of a female cell in interphase, the dark-staining, inactivated X-chromosome is called a **Barr body**. Murray Barr, a Canadian researcher, first noticed the Barr bodies in 1949 in the nerve cells of female cats. A normal male cell has no Barr bodies because the one X-chromosome remains active.

In 1961, English geneticist Mary Lyon proposed that the Barr body is the inactivated X-chromosome and that X-inactivation occurs early in development and is irreversible. Lyon reasoned that for homozygous sex-linked genes, X-inactivation would have no functional effect. No matter which X-chromosome was turned off, the same allele would be expressed. But for heterozygous genes X-inactivation causes one allele or the other to be expressed in each cell.

Once an X-chromosome is inactivated in one cell, all the cells that form when that cell divides have the same inactivated X-chromosome. Because the inactivation occurs early in development, the adult female has patches of tissues that are phenotypically different in their expression of sex-linked genes. Now that each cell in her body has only one active X-chromosome, she is numerically equivalent to the male in genetic makeup.

X-inactivation has a valuable medical application in detecting carriers of some sex-linked disorders.

Geneticists can identify carriers of **Duchenne Muscular Dystrophy** (DMD) by demonstrating inactivation. A carrier for DMD has truly hybrid muscle structure. She may have mildly weak muscles and produce enzymes that indicate some of her muscle tissue breaking down.

Key Concepts

In mammals, X-inactivation evens the differences in the number of genes males and females carry on the X-chromosome. Early in a female's development, one X-chromosome in each cell is turned off. X-inactivation can cause noticeable effects when heterozygous alleles are each expressed in different tissues.

Sex-limited Traits :

A sex-limited trait affects a body structure or function present in only one sex. The gene that controls such a trait may be sex-linked or autosomal, and it may be difficult to distinguish between the two. Sex-limited inheritance is important in animal breeding. In cattle, for example, traits such as milk yield and horn development affect only one sex, but either parent may transmit the genes that control these traits. In humans, beard growth and breast size are sex-limited traits. A woman cannot grow, a beard because she does not manufacture the hormones needed to grow facial hair. She can, however, pass the genes specifying heavy beard growth to her sons.

Sex-limited inheritance is important to consider in diagnosing breast cancer.

Sex-influenced Traits :

In a sex-influenced trait, an allele is dominant in one sex but recessive in the other. Hormonal differences can cause this difference in expression. For example, a gene for hair growth pattern has two alleles, one that produces hair all over the head and another that causes pattern baldness. The baldness allele is dominant in males but recessive in females. A heterozygous male is bald but a heterozygous female is not.

Genomic Imprinting :

In a genomic imprinting, the expression of a disorder differs depending upon which parent transmits the disease-causing gene or chromosome. The phenotype may differ in degree of severity, age of onset, or even in the nature of the symptoms.

X-inactivation in mammals is a broad example of genomic imprinting—many genes on the X-chromosome are inactivated in female but not in a male. Genomic imprinting also appears in the Angelman and Prader-Willi syndromes. In these two disorders affecting the same region of chromosome 15, different sets of symptoms arise depending upon the sex of the parent transmitting the gene. Genomic Imprinting also plays a role in juvenile diabetes, some forms of asthma and hay fever. Huntington disease and certain childhood cancers

Genetic Heterogeneity :

The four modes of Mendelian inheritance reflect the location of genes on chromosomes. They are :

Autosomal recessive
Autosomal dominant
Sex-linked recessive
Sex-linked dominant

The same phenotype may result from genes inherited in different ways. A trait or disorder exhibits **genetic heterogeneity** if a different single gene causes the trait in different individuals. Genetic heterogeneity can occur when gene's products act at different points in the same biochemical pathway, ultimately affecting the same biological function.

Key Concepts

The same genes may be expressed differently in each sex, and, conversely, different genes may cause the same trait or disorder in different individuals. A sex-limited trait affects only one gender. A sex-influenced allele is dominant in one sex but recessive in the other. In genomic imprinting, the phenotype differs depending on whether a gene is inherited from the mother or the father. Because of genetic heterogeneity, different mutant genes can result in the same phenotype.

Some Disease-related Genes on the Human X-Chromosome *

Condition	Description
Eye	
Green colour blindness	Abnormal green cone pigments in retina
Megalocornea	Enlarged cornea
Norrie disease	Abnormal growth of retina, eye degeneration
Ocular albinism	Eye lacks pigment
Red colour blindness	Abnormal red cone pigments in retina
Retinitis pigmentosa	Constriction of visual field, night blindness, clumps of pigment in eye.
Retinoschisis	Retina degenerates and splits
Inborn Errors of Metabolism	
Agammaglobulinemia	Lack of certain antibodies
Chronic granulomatous disease	Skin and lung infections, enlarged liver and spleen
Diabetes insipidus	Copious urination
Fabry disease	Abdominal pain, skin lesions, kidney failure
Gout	Inflamed, painful joints

G6PD deficiency and favism	Hemolytic anemia after eating fava beans
Hemophilia A	Absent clotting factor IX
Hemophilia B	Absent clotting factor VIII
Hypophosphatemia	Vitamin D-resistant rickets
Hunter syndrome	Deformed face, dwarfism, deafness, mental retardation, heart defects, enlarged liver and spleen
Ornithine transcarbamylase deficiency	Mental deterioration, ammonia accumulation in blood
Primary adrenal hypoplasia	Great disorganization of adrenal glands and resulting hormone deficiencies
Severe combined immune deficiency	Lack of immune system cells
Wiskott-Aldrich syndrome	Bloody diarrhea, infections, rash, too few platelets
Nerves and Muscles	
Charcot-Marie-Tooth disease	Loss of feeling in ends of arms and legs.
Fragile X-syndrome	X-chromosome with extra constrictions; mental retardation, characteristic face, large testicles.
Hydrocephalus	Excess fluid in brain
Lesch-Nyhan syndrome	Mental retardation, self-mutilation, urinary stones, spastic cerebral palsy
Menkes disease	Kinky hair, abnormal copper transport, brain atrophy
Muscular dystrophy, Becker and Duchenne forms	Progressive muscle weakness
Spinal and bulbar muscular atrophy	Muscle weakness and wasting
Other	
Amelogenesis imperfecta	Abnormal tooth enamel
Alport syndrome	Deafness, inflamed kidney tubules
Cleft palate	Opening in roof of mouth
Hypohidrotic ectodermal dysplasia	Absence of teeth, hair and sweat glands
Ichthyosis	Rough, scaly skin on scalp, ears, neck, abdomen and legs
Incontinentia pigmenti	Swirls of skin colour, hair loss, seizures, abnormal teeth
Kallmann syndrome	Inability to smell, under-developed testes
Testicular feminization	Male embryo does not respond to male hormones, appears female

* Some of these conditions can also be transmitted through genes on the autosomes.

OBJECTIVE QUESTIONS

1. Genes which are confined to differential region of Y-chromosome only are called—
   (A) Holandric
   (B) Autosomal
   (C) Mutant
   (D) None of the above
2. If each somatic cell of a human male contains a single Barr body in its nucleus, the most likely genetic constitution of the person is—
   (A) XO (B) XYY
   (C) XXXY (D) XXY
3. Barr body (seen in saliva test in Olympic games) is associated with—
   (A) Male sex only
   (B) Y-chromosome
   (C) X-chromosome
   (D) Autosome
4. In man sex determination depends upon chromosome present in—
   (A) Female gametes
   (B) Male gametes
   (C) Male and female gametes
   (D) None of the above
5. Foetal sex can be determined by examining cells from amniotic fluid looking for—
   (A) Barr body
   (B) Chiasmata
   (C) Sex chromosome
   (D) Kinetochores
6. Sex-linked inheritance was discovered by—
   (A) Mc-Clung
   (B) Mendel
   (C) Landsteiner
   (D) Morgan
7. Which of the following is genetically similar to haemophilia ?
   (A) Night blindness
   (B) Colour blindness
   (C) Albinism
   (D) None of the above
8. Sex of human child is determined by—
   (A) Size of sperm
   (B) Sex chromosome of mother
   (C) Sex chromosome of father
   (D) Size of the egg
9. Colour blindness and haemophilia usually affect men but the factors for these traits are transmitted in boys always by mother. This is because the factors are located in—
   (A) Y-chromosome

(Continued on Page 1824)

NERVOUS SYSTEM

The central nervous system is only part of the vertebrate nervous system. As the brain and spinal cord develop cells from the area, where the neural tube contracts surrounding ectoderm develop into the **Peripheral Nervous System** (PNS) which includes all nervous tissue outside the Central Nervous System (CNS). The PNS consists of Cranial nerves that exit the CNS from the brain and spinal nerves extending from the spinal cord as well as collections of cell bodies called **ganglia**. The PNS consists of the **sensory** (or afferent) pathways that carry information to the CNS and the **motor** (or efferent) pathways that transmit action potentials from the CNS to effectors such as muscle or gland cells. The motor pathways in turn consists of **somatic** (voluntary) **nervous system**, which leads to skeletal muscles and **autonomic** (involuntary) **nervous system**, which goes to smooth muscle, cardiac muscle and glands. Finally, the autonomic nervous system consists of the **sympathetic system**, which mobilizes the body to respond to threatening environmental stimuli and the **parasympathetic system**, which carries out more mundane functions such as respiration and heart rate at rest.

and conducting messages over long distances. The central portion of the neuron, the **cell body**, does most of the neuron's metabolic work. It contains the usual assortment of cellular organelles : a nucleus, extensive endoplasmic reticulum, mitochondria to generate the ATP needed for maintaining the neuron's readiness to send a message and ribosomes to manufacture the proteins needed to convey a message to another neuron.

The cells extensions are of two types. The shorter, branched and more numerous extensions are called **dendrites**. They receive information from other neurons and transmit it toward the cell body. The many branching dendrites allow a neuron to receive input from many other neurons. The second type extension from the cell body is an **axon** which conducts the message away from the cell body and transmits it to another cell. Because a nerve's message may have to be transmitted to a cell quite far away, an axon is usually longer than a dendrite. An axon is usually thicker than a dendrite and a neuron usually has only one axon. Axons are sometimes called nerve fibres.

Neurons are classified into three groups according to their general function. A neuron that brings information

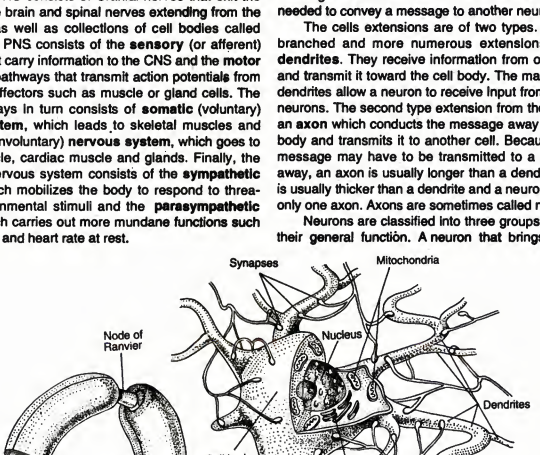


Fig. : A neuron consists of a rounded cell body, 'receiving' branches called dendrites and 'sending' branches called axons. The space between the axon terminals of one neuron and the dendrites of an adjacent neuron is the synapse. Many axons are encased in fatty myelin sheaths. Unmyelinated regions between adjacent myelin sheath cells are called nodes of Ranvier.

Functional units of the nervous system–Neurons

All neurons have the same basic parts but they vary considerably in shape and size. A neuron consists of a rounded central portion with many emanating long, fine extensions, a form well adapted to receiving, integrating

toward the central nervous system (the brain and spinal cord) is called **sensory** (or afferent) **neuron**. It has long dendrites that carry its message from a body part, such as from the skin, toward the cell body which is located just outside the spinal cord. A sensory neuron's axon is

relatively short because it delivers the message to another neuron whose dendrites are located nearby within the spinal cord.

A **motor** (or efferent) **neuron** conducts its message outward, from the central nervous system toward muscle or gland cells. It has a long axon to reach the **effector** (the muscle or gland) and short dendrites. When a motor neuron stimulates a muscle cell, it contracts and when a neuron stimulates a gland, it secretes. A third type of neuron, an **interneuron**, connects one neuron to another within the central nervous system to integrate information from many sources and coordinate responses. Large complex networks of interneurons receive information from sensory neurons, process and store this information and generate the messages carried by the motor neurons to the effector organs. Interneurons are found within the central nervous system only. It conveys messages between various parts of central nervous system, such as from one side of the brain or spinal cord to the other or from the brain to the spinal cord and vice versa. An interneuron has short dendrites and either a long axon or a short axon.

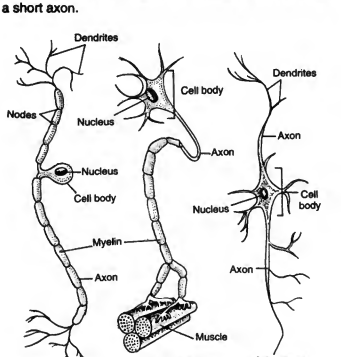


Fig. : Types of neurons. Sensory neurons transmit information from sensory receptors in contact with the environment to the central nervous system. They have long dendrites and short axons. Motor neurons send information from the central nervous system to muscles or glands; they have long axons and short dendrites. Interneurons connect other neurons.

The dendrites and axons of these neurons are sometimes called fibres, or processes. Most long fibres, whether dendrite or axon, are covered by a white **myelin sheath** formed from the membranes of the tightly spiraled neurolemmocytes (**Schwann cells**) surrounding these fibres. Neurolemmocytes are one of the several types of neuroglial cells in the nervous system. Neuroglial cells service the neurons and have supportive and nutritive functions.

A Neuron's Message

The message that a neuron conducts is called a **nerve impulse**. This is an electrochemical change that occurs when ions move across the cell membrane. A measurement called an **action potential**.

The Resting Potential

Resting Potential is baseline. The inside of a resting neuron (one not conducting an impulse) carries slightly negative electrical potential relative the outside. When the axon is not conducting an impulse the **oscilloscope** records a membrane potential equal to about – 65 mV (millivolts), indicating that the inside of the neuron is more negative than the outside. This is called the **resting potential** because the axon is not conducting an impulse.

A membrane in this condition is charged or **polarized** because the inside and outside carry different electric charges. The charge differences across the membrane results from the unequal distribution of sodium ions (K^+). The concentration of K^+ is 30 times greater inside the cell than outside and the concentration of Na^+ is 10 times greater outside than inside. Although the K^+ concentration might appear to give the neuron interior a positive charge, the inside of a neuron at rest is negative because an even greater number of negatively charged proteins and ions are trapped there.

The cell membrane is **selectively permeable**; it admits some substances but not others. Ions move through the membrane through small pores called channels. Some channels are always open but others open or close depending on protein gates that change shape to block or clear the channel. These gates are voltage regulated—whether a gate opens or closes depends upon the electrical charge of the membrane. Some membrane channels are specific for Na^+ and others are specific for K^+.

Another property of the membrane that establishes and maintains ion distribution is the **sodium-potassium pump**, a mechanism that uses cellular energy (ATP) to transport Na^+ out and K^+ into the cell. The sodium-potassium pump uses active transport to move Na^+ and K^+ against their concentration gradients.

Within the limits these membrane properties impose, ions distribute themselves in response to two forces. First, ions follow an **electrical gradient**. Like charges (negative and negative; positive and positive) tend to repel one another. Unlike charges (negative and positive) attract one another. Second, ions follow a **concentration gradient**. Ions passively diffuse from an area in which they are highly concentrated toward an area of lower concentration. So a particular ion will enter or exit the cell depending upon that ion's concentrations on each side.

The basic mechanisms are at work in establishing and maintaining the resting potential. First, the sodium-potassium pump, using ATP for energy, concentrates K^+ inside the cell and Na^+ outside. The pump ejects three Na^+ for every two K^+ it pumps in. Second, large negatively charged proteins and other negative ions are trapped inside the cell because the cell membrane is not

permeable to them. Third, the membrane in the resting state is 40 times more permeable to K^+ than to Na^+.

These three mechanisms set up the conditions required to establish the resting potential. Because of the concentration gradient and high permeability, K^+ is able to diffuse out of the cell. As K^+ moves through the membrane to the outside of the cell, it carries a positive charge with it, leaving behind the large, negatively charged molecules. A charge or potential is, therefore, established across the membrane's positive on the outside and negative on the inside. The magnitude of the charge is determined by the balance of opposing forces acting on K^+ outward and the negative charge inside the cell tends to hold K^+ in. When these two opposing forces are equal, no net movement of K^+ occurs and the cell is in equilibrium. At this time, the cell is uniformly charged over its entire surface and resting potential is established.

The importance of the sodium-potassium pump in maintaining resting potential becomes evident when a metabolic poison such as cyanide disables the pump. K^+ slowly diffuses out and Na^+ in, destroying the concentration gradients. Nerve transmission is then impossible because a charge no longer exists across the membrane. Death occurs in minutes.

It is curious that the neuron uses more energy while resting than it does conducting an impulse. Presumably, expending energy to maintain a resting potential, allows the neuron to respond more quickly that it could if it had to generate a potential difference across the membrane each time it received a stimulus.

KEY CONCEPTS

In the resting state, the inside of a neuron is negative compared to the outside due to the unequal ion distribution. Three mechanisms establish and maintain these ion concentrations. First, the selectively permeable membrane holds large, negatively charged proteins within the cell. Second, the membrane allows K^+ to flow outward, following its concentration gradient and carrying a positive charge out with it. Third, the sodium-potassium pump actively pumps Na^+ out and K^+ in to maintain the concentration gradients. These mechanisms establish a negative charge within the cell so that the neuron is always charged and ready to respond to stimuli.

The Action Potential

If the axon is stimulated to conduct a nerve impulse by an electric shock, a sudden change in pH, or a pinch, there is a rapid change in the polarity recorded as a trace on the osciloscope screen. This change in polarity is called the **action potential**. In action potential sodium ions move to the inside making it positive compared to outside (+ 40 mV).

During an action potential, Na^+ and K^+ quickly redistribute across a small patch of the cell membrane, creating an electrochemical change that moves like a wave along the nerve fibre. An action potential begins when a stimulus (a change in pH, a touch, or a signal from another neuron) changes the permeability of the membrane so that some Na^+ begins to leak into the cell. As Na^+ enters the neuron, the interior becomes less negative. The membrane is depolarized, or loses its charge, because of the influx of Na^+ when enough Na^+ enters to depolarize the membrane to a certain point (the 'threshold'), the sodium gates in that area of the membrane open, increasing permeability to Na^+. Driven by both the electrical gradient and the concentration gradient, Na^+ floods the inside of the cell so that the interior becomes positively charged. Na^+ influx continues until the positive charge peaks.

At this peak of the action potential, membrane permeability changes again. Permeability to Na^+ halts as sodium gates close but permeability to K^+ suddenly increases as potassium gates open. Now Na^+ cannot enter in large numbers. However, K^+ exodus begins, driven by both electrical and concentration gradients. K^+ flows outwards because it is more concentrated inside than outside and because the inside of the membrane is now positively charged due to the influx of Na^+.

The loss of positively charged K^+ restores the negative charge to the interior of the cell, repolarizing the cell membrane. The electrical potential fleetingly drops below the resting value because the K^+ gates stay open slightly longer than the Na^+ gates. This slight increase in negative charge is corrected when the sodium-potassium pump 'resets' the membrane potential to the resting state.

KEY CONCEPTS

An action potential is transmitted as a depolarization and repolarization of the neuron membrane. It begins when a stimulus (chemical, electrical, or change in pressure) changes the permeability of the membrane so that Na^+ begins to leak into the cell. When enough Na^+ enters, the sodium gates open and these ions rush inside, making the interior of the cell positive. The positive charge inside the membrane triggers the sodium gates to close and increases permeability to K^+. K^+ then rushes out of the cell, eventually restoring the negative resting potential inside. The shift in ions in one area triggers the same changes in the next area. As a result, a wave of depolarization and repolarization travels along the axon. All action **potentials are of the same magnitude. Differences in allmulus intensity are communicated by action potential frequency**.

While the Na^+ and then the K^+ gates are open, a second action potential cannot begin. Still, an action potential takes only 1 to 5 milliseconds. This capacity to rapidly transmit nerve impulses makes the nervous system an effective communication network.

The characteristic changes in membrane permeability that constitute the action potential travel along the neuron, usually from dendrite to cell body and down an axon. The action potential spreads because some of the Na^+ rushing into the cell at a particular point moves to the neighbouring part of the neuron. The establishment of a positive charge in the nearby region triggers an influx of Na^+ these, carrying the action potential forward. An action potential is, therefore, an all-or-none phenomenon, either happens or does not.

Neurons recognise the intensity of a stimulus according to the frequency of action potentials. Whereas a light touch to nerve endings in the skin might produce 10 impulses in a given time period, a hard hit might generate 100 impulses, intensifying the sensation. Neurons also recognise the type of stimulation.

The Myelin Sheath and Saltatory Conduction

Not all nerve fibres conduct action potentials at the same speed. Speed of conduction depends on certain chracteristics of the fibre. The greater the diameter of the fibre, the faster it conducts an action potential. However, thin vertebrate nerve fibres can conduct action potentials very rapidly when coated with a fatty material called a **myelin sheath**.

Outside the brain and spinal cord, **Schwann cells**, which contain enormous amounts of lipid, form myelin sheaths. A Schwann cell wraps around an axon many times, forming a whitish coating. Each of many Schwann cells wraps a small segment of the axon to form a sheath. Between each Schwann cell is a short region of exposed axon called a **node of Ranvier**. Some neurons in the brain and spinal cord are wrapped in myelin produced by cells called **Oligodendrocytes**.

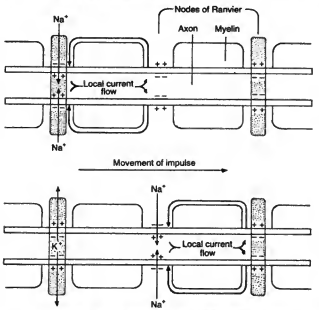


Fig. : Saltatory conduction. In myelinated axons, action potentials 'jump' from one node of Ranvier to the next.

When an action potential travels along a myelinated axon, it '**jumps**' from node to node in a type of transmission called **saltatory conduction**. The impulse leaps from node to node because the myelin insulation prevents ion flow but a small electric current spreads instantly between nodes. An action potential moves faster when it jumps from node to node. Saltatory conduction thus increases the speed of nerve transmission. Myelinated axons may conduct action potentials 100 times faster than unmyelinated axons, at speeds of up to 120 metres per second. This means that a sensory message travels from the toe to the spinal cord in less than 1/100th of a second.

Myelinated fibres are found in pathways that transmit impulses over long distances. They make up the white matter of the nervous system. Cell bodies and interneurons that lack myelin usually specialize in interpreting multiple messages. These unmyelinated fibres, the gray matter of the nervous system, make up much of the nerve tissue in the brain and spinal cord.

KEY CONCEPTS

Neurons outside the brain and spinal cord are wrapped in myelin sheaths formed by fatty Schwann cells. Between the Schwann cells lie unmyelinated nodes of Ranvier and action potentials jump between these nodes. Saltatory conduction from node to node permits the action potential to be transmitted rapidly through the nervous system.

Synaptic Transmission

To form a communication network, a neuron must convey its message, the action potential, to another neuron (or a muscle or gland cell). Neurons do not actually touch each other, so the action potential cannot travel directly from cell to cell. Instead, the action potential is converted into a chemical signal which travels from a 'sending' cell to a 'receiving' cell across a tiny space. Once across this space, this **neurotransmitter** chemical alters the permeability of the receiving cells membrane, either provoking or preventing an action potential.

The space between neurons is called a **synapse.** The end of an axon has tiny branches that enlarge at the tips to form synaptic knobs and these knobs contain many synaptic vesicles, small sacs that hold neurotransmitter molecules. An action potential passes down the axon of the **presynaptic cell,** the cell sending the message. When the action reaches the membrane near the space, or **synaptic cleft,** the permeability of the membrane changes and calcium ions enter the cell. The calcium ions cause the vesicles containing neurotransmitter molecules to move toward the synaptic membrane, fuse with it and dump their contents into the synaptic cleft by exocytosis.

Neurotransmitter molecules diffuse across the cleft and attach to protein receptors on the membrane of the receiving neuron (the **postsynaptic cell**). A particular neurotransmitter fits only into a specific receptor type as a key fits only a certain lock. When the neurotransmitter attaches to the receptor, the conformation (three dimensional shape) of the receptor protein changes, opening channels in the postsynaptic membrane and allowing specific ions to flow through and change the probability that an action potential will be generated.

Disposal of Neurotransmitters

A neurotransmitter does not linger in the synapse. If it did, its effect on the receiving cell would be continuous, perhaps causing it to fire unceasingly and bombarding the nervous system with stimuli. However, because a neurotransmitter is either destroyed by an enzyme or taken back into the presynaptic axon soon after its release, chemical chaos is avoided. For example, the

enzyme acetylcholinesterase breaks down acetylcholine into its component parts, acetate and choline. The axon then absorbs and uses these components to resynthesize acetylcholine. An acetylcholine molecule must work with lightning speed, for it probably has no more than 1/500 of a second to act before its destruction. Other neurotransmitters, such as adrenaline, noradrenaline and serotonin, are reabsorbed by the presynaptic cell.

If a neurotransmitter is not quickly destroyed, dire consequences may ensue. For example, nerve gas and certain insecticides block acetylcholine breakdown by inhibiting acetylcholinesterase. As a result, acetylcholine is not destroyed and stays active in the synapse. This stimulates skeletal muscle to contract continuously and the victim convulses and dies. The twitching legs of a cockroach sprayed with insecticide demonstrate the effects of blocking acetylcholine breakdown.

Synaptic Integration – A Neuron's Response

The nervous system has two types of synapses. **Excitatory synapses** depolarize the post synaptic membrane and **inhibitory synapses** increase the polarization (hyperpolarize it). A neurotransmitter that acts at an excitatory synapse increases the probability that an action potential will be generated in the second neuron by slightly depolarizing it. For example, when acetylcholine binds to the receptors at an excitatory synapse, channels open that admit Na^+ into the post-synaptic cell. In just a milli second, these channels let half a million sodium ions flow in. If enough Na^+ enters to reach a threshold level of depolarization, it triggers an action potential in the post-synaptic cell.

On the other hand, a neurotransmitter may inhibit an action potential in the post-synaptic cell by making the cell's interior more negative than the usual resting potential. In this case, extra Na^+ must enter before the membrane becomes depolarized enough that an action potential is generated.

The combination of excitatory and inhibitory synapses provides finer control over a neuron's activities. A single neuron in the nervous system may receive input from thousands of other neurons, some excitatory and others inhibitory. Nearly half of its receiving surface adjoins synapses. Whether that neuron transmits an action potential depends on the sum of the excitatory and inhibitory impulses it receives. If it receives more excitatory impulses, the post-synaptic cell is stimulated, if inhibitory messages predominate, it is not. A neuron's evaluation of impinging nerve messages, which determines whether an action potential is 'fired', is termed neural or synaptic integration.

Synapses markedly increase the informational content of the nervous system. The human brain has a trillion neurons, which can be viewed as bits of information. But if a synapse is also considered a unit of information, then the informational capacity of the brain increases a thousand fold, because a typical brain neuron has synaptic connections to a thousand other neurons, each sending or receiving messages hundreds of times per second.

Types of Neurotransmitters

The peripheral nervous system (the part outside the brain and spinal cord) uses three neurotransmitters ... acetylcholine, noradrenaline and adrenaline. The central nervous system (the brain and spinal cord) uses many additional transmitters. Among many neurotransmitters found in the central nervous system are dopamine, serotonin, the inhibitory transmitter GABA (Gamma Amino Butyric Acid) and the fascinating internal opiates, endorphins. Scientists once believed that a single neuron could produce only one neurotransmitter. However, some neurons produce more than one transmitter, releasing the same combination at each synapse. Different neurotransmitters seen to be associated with particular behaviours or responses.

Peripheral Nervous System (PNS)

The peripheral nervous system lies outside the central nervous system. The peripheral nervous sytem (PNS) is made up of **nerves** which are part of either the **somatic system** or the **autonomic system**. The somatic system contains nerves that control skeletal muscles, skin and joints. The autonomic system contains nerves that control the smooth muscles of the internal organs and the glands. Nerves are structures that contain many long fibres–long dendrites and/or long axons. Each of these fibres is surrounded by a myelin sheath and, therefore, these nerves have a white, glistening appearance. There are no cell bodies in nerves because cell bodies are found only in the central nervous system or in the ganglia. **Ganglia** are collections of cell bodies found particularly within the peripheral nervous system.

Humans have **twelve pairs of cranial nerves** attached to the brain. Cranial nerves are either sensory nerves (having long dendrites of sensory neurons only), motor nerves (having long axons of motor neurons only), or mixed nerves (having both long dendrites and long axons). With the exception of the **vagus nerve**, all cranial nerves control the head, neck and face. The vagus nerve controls the internal organs.

Humans have **thirty one pairs of spinal nerves**. Each spinal nerve emerges from the spinal cord by two short branches, or roots, which lie within the vertebral column. The dorsal root contains the fibres of sensory neurons which conduct impulses to the cord. The ventral root contains the axons of motor neurons which conduct impulses away from the spinal cord. These two roots join just before a spinal nerve leaves the vertebral column. Therefore, all spinal nerves are **mixed nerves** that take impulses to and from the **spinal cord**. Their arrangement shows that humans are segmented animals : there is a pair of spinal nerves for each segment. Spinal nerves project from the spinal cord, which is a part of the central nervous system. The spinal cord is a thick, whitish nerve cord that extends longitudinally down the back, where it is protected by the vertebrae. The cord contains a tiny **central canal** filled with cerebrospinal fluid, gray matter consisting of cell bodies and short fibres and white matter consisting of myelinated fibres.

Summary of the Human Cranial Nerves

No.	Name	Origin	Distribution	Nature	Function
I	Olfactory	Olfactory lobe	Olfactory epithelium	Sensory	Smell
II	Optic	Side of diencephalon	Retina	Sensory	Sight
III	Oculomotor	Floor of midbrain	Four eye muscles	Motor	Movement of eyeball
IV	Pathetic (Trochlear)	Floor of midbrain	Superior oblique eye muscle	Motor	Rotation of eyeball
V	Trigeminal	Ventral side of pons	—	Mixed	Sensations of touch and taste
	(i) Ophthalmic	—	Skin of nose, eyelids, forehead, scalp, conjunctiva, lacrimal gland	Sensory	—
	(ii) Maxillary	—	Mucous membrane of cheeks and upper lip and lower eyelid	Sensory	—
	(iii) Mandibular	—	Lower jaw, lower lip, pinna, tongue	Mixed	—
VI	Abducens	Ventral side of medulla	External rectus eye muscle	Motor	Rotation of eyeball
VII	Facial	Side of medulla	Face, neck, taste buds, salivary glands	Mixed	Taste, mastication, facial expression, saliva secretion, neck movement
VIII	Auditory	Side of medulla	Internal ear	Sensory	Hearing, equilibrium
IX	Glossopharyngeal	Side of medulla	Muscles and mucous membrane of pharynx and tongue	Mixed	Taste, pharyngeal contractions, saliva secretion
X	Vagus	Side of medulla	Larynx, lungs, heart, stomach, intestines	Mixed	Visceral sensations and movements
XI	Accessory spinal	Side of medulla	Muscles of pharynx, larynx, neck and shoulder	Motor	Movements of pharynx, larynx, neck and shoulder
XII	Hypoglossal	Ventral side of medulla	Muscles of tongue	Motor	Movements of tongue

Somatic System includes all nerves that serve the musculoskeletal system and the exterior sense organs, including those in the skin. Exterior sense organs are **receptors** which receive environmental stimuli and then initiate nerve impulses. Muscle fibres are **effectors** which bring about a reaction to the stimulus.

KEY CONCEPTS

The peripheral nervous system consists of all nervous tissue outside the central nervous system. The PNS has sensory pathways (from sensory receptor to CNS) and motor pathways (from CNS to muscles or glands). Motor pathways of the somatic system transmit sensations and stimulate voluntary muscles. Motor pathways of the autonomic nervous system convey involuntary impulses to smooth and cardiac muscle and glands. Within the autonomic nervous system, sympathetic nerves control physical responses to threatening situations and parasympathetic nerves maintain normal functioning in nonthreatening situations.

Autonomic Nervous System

The autonomic nervous system enables internal organs of body to function properly without our conscious awareness by transmitting impulses to smoth muscles, cardiac muscle and glands. The autonomic system is a part of the peripheral nervous system (PNS) and made up of motor neurons that control the internal organs automatically and usually without need for conscious intervention. The sensory neurons that come from the internal organs allow us to feel internal pain. The cell bodies for these sensory neurons are in dorsal-root ganglia, along with the cell bodies of somatic sensory neurons.

There are two divisions of the autonomic system : the **sympathetic** and **parasympathetic systems**. Both of these function automatically and usually subconsciously in an involuntary manner; innervate internal organs; and utilize two motor neurons and one ganglion for each impulse. The first of these two neurons has a cell body within the central nervous system and a **pre-ganglionic fibre**. The second neuron has a cell body within the ganglion and a **post-ganglionic fibre**. **Auerbach's plexus** is that part of autonomic nervous system (mostly from the vagus nerve) lying between the two main muscle layers of the gut and controlling its peristaltic movements.

Sympathetic System—Most pre-ganglionic fibres of the **sympathetic system** arise from the middle, or **thoracic-lumbar** portion of the spinal cord and almost immediately terminate in ganglia that lie near the cord. Therefore, this system is often referred to as the **thoracolumbar** portion of the autonomic system. In the sympathetic system, the pre-ganglionic fibre is short, but the post-ganglionic fibre that makes contact with an organ is long.

The sympathetic system is especially important during emergency situations and is associated with 'fight or flight'. The sympathetic system accelerates the heartbeat, dilates the bronchi and increases the breathing rate. On the other hand, the sympathetic system inhibits the digestive tract-digestion is not an immediate necessity if one is under attack. The neurotransmitter released by the post-ganglionic axon is primarily norepinephrine (NE), a chemical close in structure to epinephrine (adrenaline), a medicine used as a heart stimulant. The sympathetic fibres are adrergic.

fibre is long and the post-ganglionic fibre is short because the ganglia lie near or within the organ.

The parasympathetic system, sometimes called the 'house-keeper system', promotes all the internal responses which are associated with a relaxed state; for example, it causes the pupil of the eye to contract, promotes digestion of food and retards the heartbeat. The neurotransmitter utilized by the parasympathetic system is acetylcholine (ACh). Thus the parasympathetic system brings about the responses associated with a relaxed state.

Differences between Sympathetic and Parasympathetic Nervous Systems

Sympathetic Nervous System	Parasympathetic Nervous System
1. Its components are consolidated so as to have a visibly distinct anatomical entity.	1. Its components are isolated and do not have a visibly distinct form.
2. Its ganglia are linked up to form a chain.	2. Its ganglia remain isolated.
3. Its preganglionic fibres emerge with spinal nerves only (thoracolumbar outflow).	3. Its preganglionic fibres emerge with cranial as well as spinal nerves (craniosacral outflow).
4. Its pre-ganglionic fibres branch, enter several ganglia and transmit nerve impulses to many post-ganglionic fibres. Therefore, they produce a widespread effect.	4. Its pre-ganglionic fibres do not branch, each enters a single ganglion and transmits nerve impulses to a single post-ganglionic fibre. This produces a limited effect.
5. Pre-ganglionic fibres are shorter than the post-ganglionic fibres.	5. Pre-ganglionic fibres are much longer than the post-ganglionic fibres.
6. Post-ganglionic fibres are numerous and are mostly adrenergic.	6. Post-ganglionic fibres are fewer and are cholinergic.
7. Overall effect is excitatory.	7. Overall effect is inhibitory.
8. Active during stressful conditions, preparing the body to face them.	8. Active during relaxing times, restoring normal activity after stress.
9. Area of influence is diffuse.	9. Area of influence is localized.

Parasympathetic System—A few cranial nerves, including the vagus nerve, together with fibres that arise from the **sacral** portion of the spinal cord, form the **parasympathetic system**. Therefore, this system is often referred to as the **Craniosacral portion** of the autonomic system. In the parasympathetic system, the pre-ganglionic

Thus parasympathetic nerve fibres are **cholinergic** and in humans are found as motor components of cranial nerves III, VII, IX and X, as well as of three spinal nerves in sacral segments 2–4. Most of its effects are brought about by its distribution in the vagus (X), serving the gut, liver and heart among other organs.

Summary of the Effects of Sympathetic and Parasympathetic Nervous Systems on Major Organs

Organ	Sympathetic Nervous System	Parasympathetic Nervous System
Eye	Dilates pupil	Constricts pupil
Salivary Glands	Inhibits secretion of saliva	Stimulates secretion of saliva
Gut	Inhibits peristalsis	Stimulates peristalsis
	Inhibits secretion of digestive juices	Stimulates secretion of digestive juices
Lungs	Dilates bronchi and bronchioles	Constricts bronchi and bronchioles
	Accelerates breathing rate	Slows breathing rate
Heart	Increases the force and rate of heartbeat	Decreases the force and rate of heartbeat
	Raises blood pressure	Lowers blood pressure
Bladder	Contracts bladder sphincter	Inhibits contraction of bladder sphincter
Penis	Induces ejaculation	Stimulates erection

Reflexes

Reflexes are automatic, involuntary responses to changes occurring inside or outside the body. In the somatic system, outside stimuli often initiate a reflex action. Some reflexes, such as blinking the eye, involve sudden stimuli. A number of reflex responses, therefore, occur in the daily life of animals.

Reflex arc—The entire impulse circuit of a reflex response—receptors → CNS → effectors — is called a **reflex arc**. It is the **basic functional unit** of nervous system.

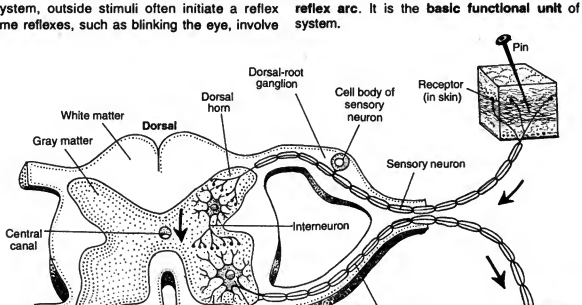


Fig. : Reflex arc

brain, but others, such as withdrawing the hand from a hot object, do not necessarily involve the brain. The reflex action involving the spinal cord and a spinal nerve is called **spinal reflex or reflex arc**. The reflex action controlled by brain is called **cerebral reflex action**.

If one touches a very hot object, a receptor in the skin generates nerve impulses, which move along the dendrite of a sensory neuron toward the cell body and the central nervous system. The cell body of a sensory neuron is located in the dorsal-root ganglion, just outside the cord. From the cell body, the impulses travel along the axon of the sensory nerve. The impulses then pass to many interneurons, one of which connects with a motor neuron. The short dendrites and the cell body of the **motor neuron** lead to axon, which leaves the spinal cord by way of the ventral root of the spinal nerve. The nerve impulses travel along the axon to muscle fibres which then contract so that hands are withdrawn from the hot object. Whole series of responses occur because the sensory neuron stimulates several interneurons. They take impulses to all parts of the central nervous system, including the cerebrum which in turn makes the person conscious of the stimulus and his or her reaction to it. This is a type of **'flexion reflex'**.

Reflex responses obviously occur very fast; as such one does not even feel the stimulus, because reaction or response occurs without the sensory impulse being carried to the brain centres for analysis. Thus, reflex reactions protect the body against injurious effects of

Monosynaptic and polysynaptic reflexes—Reflexes in which sensory impulses are directly transferred from sensory neurons to motor neurons are called **monosynaptic**. Such reflexes are uncommon. Usually a number of small neurons, called **association** or **internuncial neurons** or **interneurons**, present in the gray matter of CNS, serve to transfer a reflex impulse from sensory neurons to the motor neurons. Such reflexes are, therefore, called **polysynaptic**. Interneurons can carry impulses of reflex responses to the effectors located at considerable distances from receptors.

Unconditioned reflexes—Normally, reflexes are genetic and inherited, hence present at birth. These occur unknowingly, hence a previous experience is not a prerequisite for these. Animals other than mammals can hardly bring about a change in these. All instinctive behaviour of animals, like seasonal breeding, courtship, migration, etc. fall under this category of reflexes and are called **unconditioned reflexes**.

Conditioned reflexes—Reflexes developed by training and learning are called **conditioned or acquired reflexes**. For example, after proper learning, one can perform dancing, cycling, swimming, singing, playing, driving etc., simply by reflexes. Such reflexes thus fall under **learned behaviour**. During learning, these activities occur under cerebral control but once established, these occur by habit as reflexes.

Conditioned reflexes were first demonstrated by the Russian scientist, Pavlov in dogs.

Molecular Mechanisms of Nervous System Disease

Mechanism	Representative Disorder	Symptoms/Causes
Adhesion protein abnormality	Kallmann syndrome	Embryonic neutral cells cannot migrate to parts of brain controlling smell perception and gonad maturation. Symptoms are lack of smell and immature gonads.
Enzyme deficiency	Tay-Sachs disease	Nervous system degenerates in early childhood due to excess myelin on nerves. Deficient enzyme cannot break down myelin.
Neurotransmitter imbalance	Myasthenia gravis	Muscles progressively weaken because of deficient acetylcholine at nerve-muscle junctions caused by autoimmune attack.
Oxygen free radical damage	Amyotrophic lateral sclerosis (Lou Gehrig disease)	Mutant superoxide dismutase cannot stop oxygen free radical damage which causes adult onset progressive muscle weakness and paralysis due to degeneration of lower motor neurons in spinal cord and upper motor neurons in cerebral cortex.
Protein excess	Familial Alzheimer disease	Amyloid protein deposits build up in cerebrum, impairing function.
Signal transduction block	Lissencephaly (smooth brain)	Cerebral cortex is smooth because lack of signal transduction protein prevents certain neutrons from migrating to area during prenatal development.
Unstable triplet repeats	Huntington disease	Extra copies of a DNA base triplet occur in a gene on chromosome 4. Symptoms are personality changes and uncontrollable, dancelike movements.

OBJECTIVE QUESTIONS

1. Visceral and somatic sensory fibres respectively reach the spinal cord via—
   (A) Dorsal roots only
   (B) Dorsal and ventral roots
   (C) Ventral and dorsal roots
   (D) Ventral roots only
2. Cytons of both central and autonomic sensory fibres are located in—
   (A) Autonomic ganglia
   (B) Spinal ganglia
   (C) Ventral part of spinal cord
   (D) Dorsal part of spinal cord
3. Nerve fibres in lateral funiculus of spinal cord are—
   (A) Sensory only
   (B) Sensory and motor
   (C) Motor only
   (D) Not differentiated
4. Nerve fibres of roots of spinal nerves are—
   (A) Motor or efferent
   (B) Mixed
   (C) Sensory or afferent
   (D) None of the above
5. Saltatory conduction of nerve impulses occurs in—
   (A) Amyelinated fibres
   (B) Myelinated fibres
   (C) Both A and B
   (D) None of the above
6. Synaptic fatigue is due to—
   (A) Exhaustion of neuratransmitter
   (B) Release of more adrenaline
   (C) Release of more acetylcholine
   (D) None of the above
7. Which of the following is the function of parasympathetic nervous system ?
   (A) Acceleration of heartbeat
   (B) Constriction of pupil
   (C) Stimulation of sweat glands
   (D) Contraction of arrector pilli muscles
8. Most post-ganglionic sympathetic fibres terminally release—
   (A) Acetylcholine
   (B) Dopamine
   (C) Norepinephrine
   (D) None of the above
9. Reflex action is comparatively more rapid because it has to pass through—
   (A) Pituitary cortex
   (B) All along the spinal cord
   (C) Cerebral cortex
   (D) Olfactory lobes
10. Sensory nerve fibres enter into spinal cord through—
    (A) Ventral root
    (B) Dorsal root
    (C) Both A and B
    (D) None of the above

11. Secretion of parasympathetic nerve endings is—
(A) Noradrenaline
(B) Glycine
(C) Acetylcholine
(D) Hydroxy-triptamine

12. The cranial nerve which supplies regions of body and is longest—
(A) Auditory (B) Oculomotor
(C) Vagus (D) Trochlear

13. In case of spinal nerves, the cell bodies of afferent fibres lie in—
(A) Gray matter
(B) White matter
(C) Dorsal root
(D) Ventral root

14. Which cranial nerves are purely sensory ?
(A) I, II and VIII
(B) I, II and IV
(C) I, V and VII
(D) None of the above

15. Parasympathetic nervous system—
(A) Increases heartbeat
(B) Initiates heartbeat
(C) Decreases heartbeat
(D) Has no effect upon heartbeat

16. Synapse is a gap between adjacent—
(A) Muscle fibres
(B) Nerve cells
(C) Nerve cell bodies
(D) None of the above

17. A nerve which conveys impulses from a tissue to nerve centre is called—
(A) Efferent (B) Mixed
(C) Motor (D) Afferent

18. A ganglion of sensory neurons occur in—
(A) Dorsal horn of spinal cord
(B) Ventral root of spinal nerve
(C) Dorsal root of spinal nerve
(D) Dermis of skin

19. Which nerves transmit impulses towards central nervous system ?
(A) Oculomotor nerves
(B) Ventral root of spinal nerves
(C) Auditory nerves
(D) Abducens nerves

20. A nerve impulse which travels through nerve fibre only if its membrane suddenly becomes more permeable to ions of—
(A) Chloride (Cl^-)
(B) Potassium (K^+)
(C) Sodium (Na^+)
(D) Magnesium (Mg^{++})

21. A nerve impulse leaves a neuron via—
(A) Dendrite (B) Cyton
(C) Axon (D) Nucleus

22. The sensory ganglion concerned with spinal reflex lies in—
(A) Anterior root of spinal nerve
(B) Posterior root of spinal nerve
(C) Anterior horn of spinal cord
(D) Posterior horn of spinal cord

23. What is common between acetylcholine, noradrenaline and serotonine ?
(A) All lower blood pressure
(B) All are antidiuretic
(C) All promote appetite
(D) All are neurotransmitters

24. The dominating current during the membrane depolarization phase in an axon is—
(A) Potassium influx
(B) Chloride influx
(C) Calcium influx
(D) Sodium influx

25. Myelinated nerve fibres differ from non-myelinated nerve fibres in—
(A) Lacking nodes of Ranvier
(B) Being without Schwann cells
(C) Showing saltatory conduction of impulses
(D) Slow conduction of impulses

ANSWERS

1. (A) 2. (D) 3. (C) 4. (C) 5. (B)
6. (C) 7. (B) 8. (C) 9. (C) 10. (B)
11. (C) 12. (C) 13. (C) 14. (A) 15. (C)
16. (B) 17. (D) 18. (C) 19. (C) 20. (C)
21. (C) 22. (B) 23. (D) 24. (D) 25. (C)

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(Continued from Page 1750)

(D) Consecutive homologues of a series differ from each other by —CH_2—

14. Which one of the following is not a carbocyclic compound ?
(A) Cyclopentane
(B) Cyclobutene
(C) Pyridine
(D) Anthracene

15. An acid which is found in sugar-beets is—
(A) Butyric acid
(B) Oxalic acid
(C) Glutaric acid
(D) Acetic acid

16. Rancid butter has unpleasant smell. This unpleasant smell is due to the presence of—
(A) Succinic acid
(B) Sulphonic acid
(C) Butyric acid
(D) Hippuric acid

17. The trivial name of $CH_3—CHOHCOOH$ is—
(A) Hydroxy propionic acid
(B) Lactic acid
(C) Malic acid
(D) Cinnamic acid

18. Which one of the following is isopentylene glycol ?
(A) $CH_3—\underset{CH_3}{CH}—\underset{OH}{CH}—\underset{OH}{CH_2}$
(B) $\underset{OH}{CH_2}—\underset{CH_3}{CH}—\underset{OH}{CH}—CH_3$
(C) $CH_3—\underset{CH_3}{C}—CH_2—CH(OH)_2$
(D) None of these

19. $Cl—CH_2—CH_2—CH_2—Cl$ is known as—
(A) Propylene chloride
(B) Trimethylene chloride
(C) Propylidene chloride
(D) All are correct

20.  is named as—
(A) Cyclopentane
(B) Cyclohexane
(C) Trimethyl propane
(D) Dimethyl butane

ANSWERS

1. (C) 2. (D) 3. (C) 4. (C) 5. (B)
6. (B) 7. (A) 8. (A) 9. (B) 10. (A)
11. (A) 12. (B) 13. (B) 14. (C) 15. (C)
16. (C) 17. (B) 18. (A) 19. (B) 20. (C)

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ZOOLOGY

1. Cells of Sertoli are found in—
   (A) Islets of Langerhans and secrete glucagon
   (B) Wall of right auricle and transmit contraction waves
   (C) Testes of rabbit and nourish spermatozoans
   (D) Stomach of rabbit and produce HCl
2. The transference of genes from one chromosome to another during synapsis is termed as—
   (A) Linkage
   (B) Crossing over
   (C) Independent assortment
   (D) Dominance
3. Gonadotrophins are secreted from—
   (A) Hypothalamus
   (B) Posterior pituitary
   (C) Anterior pituitary
   (D) Gonads
4. Location of Leydig cells and secretion they produce are—
   (A) Ovary, estrogen
   (B) Liver cholesterol
   (C) Testis, testosterone
   (D) Pancreas, glucagon
5. The vital morphological and physiological units of a mammalian kidney are—
   (A) Ureters
   (B) Seminiferous tubules
   (C) Nephridia
   (D) Uriniferous tubules
6. Menstrual cycle is regulated by—
   (A) Follicle stimulating hormone
   (B) Adrenocorticotrophin hormone
   (C) Luteinizing hormone
   (D) Mammotrophin hormone
7. Demineralization of bones is caused by over-secretion of—
   (A) Epinephrine
   (B) Parathormone
   (C) Prolactin
   (D) Thyroxine
8. Function of allantois is—
   (A) Nutritive, respiratory and excretory activities of the embryo
   (B) Exchange of substances between foetus and maternal tissues
   (C) Protection of embryo from physical shocks
   (D) Both A and B
9. Bertholin's glands are present in—
   (A) Rectum and vestibule
   (B) Rectum and anus
   (C) Rectum and urinary bladder
   (D) Rectum and urethra
10. Steroid hormones are almost similar in structure to—
    (A) Cholesterol
    (B) Triglycerides
    (C) Tyrosine
    (D) Coenzyme A
11. Ultrafiltration is determined by—
    (A) Glomerular hydrostatic pressure
    (B) Colloid osmotic pressure of blood
    (C) Capsular hydrostatic pressure
    (D) All of the above
12. Micturition reflex is related to—
    (A) Urination
    (B) Ovulation
    (C) Spermiogenesis
    (D) Coupulation
13. Filtration pressure in human kidneys is about—
    (A) 10 mm Hg (B) 70 mm Hg
    (C) 45 mm Hg (D) 55 mm Hg
14. Glomerular filtrate in Bowman's capsule is—.
    (A) Hypo-osmotic to plasma
    (B) Iso-osmotic to plasma
    (C) Hyperosmotic to plasma
    (D) Both A and B
15. Columella auris is a modified—
    (A) Articular
    (B) Quadrate
    (C) Sphinthmoid
    (D) Hyomandibular
16. Pigment which helps some mammals to clearly see in the night—
    (A) Heparin
    (B) Guanin
    (C) Porphyrin
    (D) Haemoglobin
17. Rhodopsin is found is—
    (A) Rods only
    (B) Cones only
    (C) Whole of retina
    (D) Ganglion cells
18. Acetylcholine is responsible for transmission of nerve impulses through—
    (A) Cytons (B) Dendrites
    (C) Axons (D) Synapses
19. Imprinting is related to—
    (A) A young animal develops an attachment toward another animal or object
    (B) Imprinting is a rapid learning process
    (C) A type of instinctive behaviour
    (D) Both A and B
20. Caecilians are wormlike burrowers that feed on worms and other invertebrate in the soil. These are included in—
    (A) Gymnophiona
    (B) Anura
    (C) Caudata
    (D) Annelida
21. An example of Electric fish is—
    (A) Polydon spathula
    (B) Pseudopleuronectes americanus
    (C) Etheostoma stigmanum
    (D) Gymnarchus niloticus
22. Bundle of HIS is found in—
    (A) Muscles (B) Brain
    (C) Heart (D) Liver
23. In chloride shift mechanism—
    (A) Chloride contents of RBCs increase when oxygenated blood becomes deoxygenated
    (B) Diffusion of chloride ions into RBCs

(C) Bicarbonate ions diffuse into plasma
(D) All of the above

24. Match the following—
(a) Glycogenolysis
(b) Glycogenesis
(c) Gluconeogenesis
(d) Glycolysis

(1) Formation of glycogen
(2) Breakdown of glycogen
(3) Formation of pyruvic acid
(4) Formation of glucose from non-carbohydrates

	(a)	(b)	(c)	(d)
(A)	1	2	3	4
(B)	2	1	4	3
(C)	4	3	2	1
(D)	2	3	4	1

25. Glisson's capsule are found in—
(A) Liver (B) Kidney
(C) Testis (D) Ovary

26. Vitamin theory is propounded by—
(A) Hopkins and Funk
(B) Lunnin and Funk
(C) Eizkman
(D) All of the above

27. Corals—
(A) Solitary or colonial polypoid
(B) Grow as massive bodies
(C) Branched colonies
(D) All of the above

28. Vitelline glands are found in—
(A) *Taenia solium*
(B) *Nereis*
(C) *Fasciola hepatica*
(D) *Pila globosa*

29. Respiratory organs in pila are—
(A) Ctenidium
(B) Pulmonary sac
(C) Nuchal lobes
(D) All of the above

30. A thick, rounded, sieve like calcareous plate lies on arm interradius near the bases of two adjacent arms forming the bivium is known as—
(A) Madreporite
(B) Stone canal
(C) Ring canal
(D) Tiedmann's bodies

31. Excretory organ in Balanoglossus are—
(A) Proboscis gland
(B) Collar cord
(C) Antennary gland
(D) Nephridia

32. Lead arsenate is a—
(A) Stomach poison
(B) Contact poison
(C) Fumigant
(D) Both A and B

33. How many ATP molecules are formed during complete respiration ?
(A) 42 (B) 38
(C) 40 (D) 44

34. Complete combustion of glucose molecule in a calorimeter causing its breakdown into—
(A) CO_2 and H_2O yields about 686 kcal
(B) CO_2 and H_2O yields about 540 kcal
(C) CO and H_2O yields about 136 kcal
(D) CO and H_2O yields about 156 kcal

35. Transcription is the process in which—
(A) *m*-RNA is formed from DNA
(B) RNA-synthesis
(C) Assembly of ribosomes or golgi bodies
(D) Protein synthesis

36. Flight adaptation in bats is—
(A) Flight membrane
(B) Petagium
(C) Hind limbs and tail included in the wings
(D) All of the above

37. Scroll valve is found in—
(A) Intestine of sharks
(B) Intestine of tortoise
(C) Intestine of lizard
(D) Intestine of frog

38. Which of the following fish is able to live outside water ?
(A) Labeo (B) Anabas
(C) Rhodeus (D) Amia calva

39. Snakes mainly respond to—
(A) Earth-borne vibrations through the quadrate
(B) Air-borne vibrations through the quadrate
(C) Earth-borne vibrations through the squamosal
(D) Both A and B

40. Flightless birds belong to—
(A) Neornithes
(B) Ratites
(C) Archaeornithes
(D) None of the above

41. What is dodo ?
(A) Lizard which is found in Galapago islands
(B) A gull bird
(C) A bird which is exterminated by man found in island of Mauritius
(D) Flightless carnivorous bird

42. Foramen magnum is found at—
(A) Base of skull
(B) Apex of vertebral column
(C) Base of brain
(D) Base of medulla

43. Joints between human skull bones are—
(A) Immovable
(B) Imperfect
(C) Gliding
(D) Saddle

44. What is fourth ventricle ?
(A) Cavity of the hindbrain
(B) Part of the heart
(C) Part of the kidney
(D) None of the above

45. Cerebellum of brain is concerned to—
(A) Maintain posture, orientation and equilibrium of body
(B) Co-ordinating and regulating tone
(C) Contraction of voluntary muscles
(D) All of the above

46. Which one is formed during contraction in muscle fibres ?
(A) Myosin
(B) Actin
(C) Actomyosin
(D) ATP

47. Graafian follicles are formed from—
(A) Germinal epithelium of ovaries
(B) Stroma of ovaries
(C) Both of these
(D) None of these

48. Beginning of archenteron-formation in frog's development represents the stage of—
(A) Early blastula
(B) Neurula
(C) Early gastrula
(D) Late gastrula

49. Function of pineal body is—
(A) It regulates the period of puberty
(B) Seasonal and circadian sexual bahaviour
(C) Lightening the skin colours
(D) All of the above

50. Thymus has role as—
(A) Seebed of uncommitted lymphocytes
(B) Stimulator for lymphocytes to acquire specific immunity
(C) Intensifying uterine contractions
(D) Both A and B

ANSWERS

1. (C) 2. (B) 3. (C) 4. (C) 5. (D)
6. (A) 7. (B) 8. (D) 9. (A) 10. (A)
11. (D) 12. (A) 13. (A) 14. (B) 15. (D)
16. (B) 17. (A) 18. (D) 19. (D) 20. (A)
21. (D) 22. (C) 23. (D) 24. (B) 25. (A)
26. (A) 27. (D) 28. (C) 29. (D) 30. (A)
31. (A) 32. (A) 33. (C) 34. (A) 35. (A)
36. (D) 37. (A) 38. (B) 39. (D) 40. (B)
41. (C) 42. (A) 43. (A) 44. (A) 45. (D)
46. (C) 47. (A) 48. (C) 49. (D) 50. (D)

HINTS

1. These cells are laden with granules of a yellowish pigment and are called interstitial cells or cells of Leydig.
2. During crossing over exchange of genetic material takes place. Before crossing over pairing of chromosomes or synapsis gene transference is a special event.
3. Gonadotrophin are secreted from Anterior pituitary (adenohypophysis) and stimulate growth and activities of gonads.
5. Mammalian kidney is a compact mass of about two lacs (about ten to twelve lacs in man) of extremely fine and coiled tube like excretory tubules called **uriniferous** tubules or nephrons.
7. Demineralization is caused by over-secretion of parathormone which is rare and occurs usually due to overgrowth of one or more parathyroid glands.
11. Ultrafiltration is determined by three pressures (A) glomerular hydrostatic pressure (B) colloid osmotic pressure (C) capsular hydrostatic pressure. All three different type of forces are known as effective filtration pressure.
12. Micturition is urination, the process by which the urinary bladder empeties when it once filled. It is basically a reflex reaction, called 'micturition reflex'.
17. The photosensitive parts of rod and cone cells are their outer segments. In rods, this part contains a shining pigment called rhodopsin or visual purple.
20. Members of the Gymnophiona (snake like) are the caecilians. These are wormlike burrowers that feed on worms and other invertebrates in the soil.
27. Corals are solitary or colonial polypoid coelenterates living in a secreted skeleton of their own. Some grow as massive, solid structures, others as large, branched colonies. Most of these belong to class Anthozoa and a few to class Hydrozoa.
28. Vitelline glands are numerous rounded bodies, occupying the lateral zones of the body. They pour their secretions into two lateral vitelline ducts. The latter swells up in the middle to form a yolk reservoir, from which a median vitelline duct arises to meet the oviduct.
31. Excretory organs in **Balanoglossus** are proboscis gland lying in front of the central sinus and projecting into the proboscis coelom.
32. The acid form of lead arsenate ($PbHAsO_4$), a stomach poison, which is ingested by insects with food and proves fatal after giving severe respiratory failure.
35. Transcription is the process in which *m*-RNA is formed from DNA.
36. Bats are only mammals which can actually fly. For flying adaptation forelimbs modified into 'wings' second to fifth digit and support a thin skin fold, called flight membrane, web or **petaglum**.
37. Intestine of shark (scoliodon) has an internal spiral valve.
39. Snakes respond mainly to earth borne vibrations through the quadrate, although they are also quite sensitive to a narrow waveband of low frequency air borne vibrations.
40. Flightless birds or ratites such as the ostrich, cassoway and kiwi with reduced wings and no sternal keel, long legs and curly feathers.
41. The dodo (Raphus) was a bird that adapted a terrestrial habit in the island of mauritius and grow to a large size but exterminated by man in seventeenth century.
44. The cavity of the hindbrain is called fourth ventricle, is rhomboidal and limited to the anterior part of medulla oblongata.
45. Primary function of cerebellum is to maintain posture, orientation and equilibrium of body by coordinating and regulating tone and contraction of voluntary muscles, mainly according to the commands of cerebrum.
47. A number of small ovarian or graafian follicles are found embedded in the cortical stroma of an ovary. These follicles are initially formed during embryonic development by proliferation of primordial germ cells of germinal epithelium.
48. Gastrulation is a dynamic process involving critical changes in the embryo. These are epiboly and emboly. During emboly insinking of endodermal cells form double walled infolding. This formed a cavity called archenteron.
49. Pineal body secretes a hormone called melatonin. The effect of melatonin upon melanophores is antagonistic to that of the melanocytes stimulating hormone of pituitary, it stimulates concentration of melanin granules in the centre of melanophores, lightening the skin colour. Melatonin regulates the period of puberty and seasonal and circadian (daily) sexual behaviour.

●●●

Best Fifteen Questions

ZOOLOGY

1. The poison fangs of a venomous snake are modified—
   (A) Canines
   (B) Mandibular teeth
   (C) Maxillary teeth
   (D) None of the above
2. Which of the following does not directly affect the biotic potential?
   (A) Female's age at which reproduction starts
   (B) Carrying capacity of environment
   (C) Length of time a female remains fertile
   (D) Average number of offspring
3. Forests and wild life are—
   (A) Nonrenewable resources
   (B) Inexhaustible resources
   (C) Renewable resources
   (D) None of the above
4. Protein present in the matrix of cartilage is known as—
   (A) Ossein
   (B) Chondrin
   (C) Casein
   (D) Actin
5. Which of the following accelerates the movements of villi ?
   (A) Secretin
   (B) Duocrinin
   (C) Enterocrinin
   (D) Villikinin
6. Which type of animal would you be least likely to find in a grassland biome ?
   (A) Hoofed herbivore
   (B) Active carnivore
   (C) Arboreal primate
   (D) Flying insects
7. Populations termed *r*-strategists–
   (A) Have J-shaped growth curves
   (B) Have type III survivorship curves
   (C) Are usually pioneer species
   (D) All the above are correct
8. Once the demographic transition has occurred—
   (A) Both the death rate and birth rate are high
   (B) Both the death rate and birth rate are low
   (C) The death rate is high but the birth rate is low
   (D) The death rate is low but the birth rate is high
9. Morphogenesis is best associated with—
   (A) Overall growth
   (B) Induction of one tissue by another
   (C) Genetic mutations
   (D) All the above are correct
10. Which of these combinations is most likely to be present before ovulation occurs ?
    (A) FSH, corpus luteum, estrogen, secretory uterine lining
    (B) Luteinizing hormone (LH), follicle, progesterone, thick uterine lining
    (C) FSH, follicle, estrogen, uterine lining becoming thick
    (D) LH, corpus luteum, progesterone, secretory uterine lining
11. Which of these is a direct source of energy for muscle contraction ?
    (A) ATP
    (B) Creatine phosphate
    (C) Both the above A and B
    (D) Lactic acid
12. Which of the following is mismatched ?
    (A) Cerebrum—consciousness
    (B) Thalamus—motor and sensory centres
    (C) Hypothalamus—internal environment regulator
    (D) Cerebellum—motor co-ordination
13. One advantage of urea excretion over uric acid excretion is that urea—
    (A) Requires less energy to form
    (B) Can be concentrated to a greater extent
    (C) Is not a toxic substance
    (D) Requires less water to excrete
14. Pressure filtration is associated with the—
    (A) Glomerular capsule
    (B) Distal convoluted tubule
    (C) Collecting duct
    (D) All the above are correct
15. In which animal is the circulatory system not involved in gas transport ?
    (A) Mouse
    (B) Dragonfly
    (C) Trout
    (D) Sparrow

ANSWERS WITH HINTS

1. (C) 2. (B) 3. (C) 4. (B) 5. (D)
6. (C) 7. (D) 8. (B) 9. (B) 10. (C)
11. (C) 12. (B) 13. (A) 14. (A) 15. (B)

4. Cartilage is a connective tissue containing cells (chondroblasts) embedded in a matrix of solid protein (chondrin), which may have elastic or tough white fibres in it.

7. During a short period of time, some populations produce many offsprings, which require little care. Therefore, these populations usually have a survivorship curve similar to type III. These,

(Continued on Page 1801)

CHROMOSOME AND CHROMATIN

—Dipanjan Ghosh

Introduction :

Chromosome (Gk. **Chroma** = colour; **soma** = body) means **coloured body** as it is stained by some basic dyes, *viz.*, orcein, giemsa etc. The term 'chromosome' was coined by **Waldeyer** in 1888. Chromosome is a specialised structure found in metaphase or anaphase stage of cell division. This structure is made up by the organisation of chromatin.

Structure of chromosome :

During the metaphase chromatins show highest degree of condensation in a specific regular manner and thus, constitute chromosomes. Chromosome is differentiated into a constriction (sometimes two or more) known as **centromere**. The left and right side of the centromere are known as **arm**. A metaphase chromosome is made up of two sister strands called **chromatids**. They are mirror image of each other. They contain identical DNA molecules. Two chromatids are held together at the centromere.

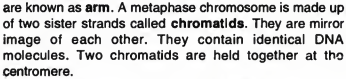


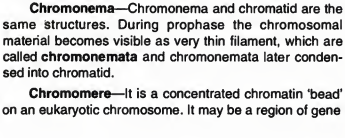
Fig. : Diagrammatic representation of a metaphase chromosome

Terminologies related to chromosome morphology :

Chromatid—At metaphase each chromosome consists of two symmetrical structures, each one of which contains a single DNA molecule. These are called chromatids. The chromatids are attached to each other only by the centromere and become separated at the start of anaphase.

Chromonema—Chromonema and chromatid are the same structures. During prophase the chromosomal material becomes visible as very thin filament, which are called **chromonemata** and chromonemata later condensed into chromatid.

Chromomere—It is a concentrated chromatin 'bead' on an eukaryotic chromosome. It may be a region of gene redandancy. It results from local coiling of a continuous thread.



Centromere—It represents the primary constriction. It is made up of highly repeatative DNA. Chromosomes show angular deviation in this region. Usually single chromosome contains solitary centromere. This condition is referred as **monocentric** chromosome. Chromosomes are classified on the basis of centromeric characters and position. The following table provides necessary informations regarding centromeric characters and positions–

Attributes	Designation
1. Centromere absent	Acentric chromosome
2. Centromere solitary	Monocentric chromosome
3. Centromeres two	Dicentric chromosome
4. Centromere diffused along the chromosomal length	Holocentric chromosome
5. Centromere median in position	Metacentric chromosome
6. Centromere submedianly placed	Submetacentric chromosome
7. Centromere located in a position close to the end	Acrocentric chromosome
8. Centromere located at one end	Telocentric chromosome

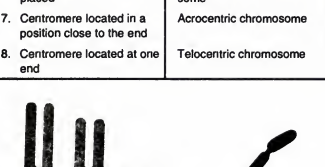


Fig. : Types of Chromosomes

Kinetochore—Centromeric portion contains disc-like proteinaceous body called **Kinetochore**. Microtubules of the spindles become connected to the kinetochore and thus the kinetochore provides a centre of assembly for microtubules. Upto 40 microtubules become connected to the kinetochore and provide the force for chromosomal movement towards the respective pole during cell division. Electron micrograph showed a trilaminar organisation of the kinetochore. These layers are outer dense, middle light and inner dense regions. The outer layer is associated with the microtubule-connection and the inner layer tightly bound to the centromeric DNA.

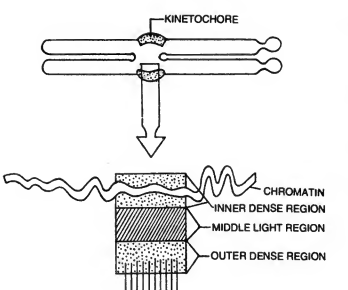


Fig. : Sectional View of Kinetochore

Telomere—Telomere is referred to the tips of the chromosomes. It is heterochromatic in nature. The special property of telomere is its non-sticky nature. Telomeres prevent the attachment on fusion of the chromosomes with each other.

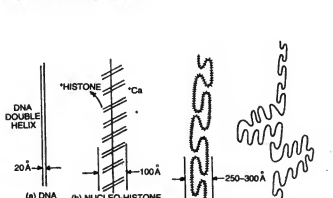
Secondary constrictions—These are constrictions other than primary constriction. Secondary constrictions are distinguished from the primary constriction by the absence of marked angular deviations of the chromosomal segments during anaphase. Secondary constriction is associated with nucleolus organisation.

Satellite—Satellite is a rounded body separated from the rest of the chromosomes by a secondary constriction. The satellite and the constriction are constant in shape and size for each particular chromosome. Satellite bearing chromosome is popularly known as **SAT chromosome**.

Organisation of Chromosome :

There are different models, *viz.*, chromosome structure model of Ris (1967), folded fibre model of Du Praw (1965, 68), radial loop model of Laemmli (1979) etc., regarding the organisation of chromosome. Among these models Laemmli's radial loop model is the modern and well accepted one to understand the organisation of chromosome.

Model-I—In his model of chromosome structure, Ris (1967) suggested that the histone is associated with the DNA and some type of coiling takes place to give a nucleo-histone fibre (100 Å). Further folding results a basic fibril of 200°–300 Å.



Model-II—The 'Folded fibre model' of Du Praw (1965, 68) represents the chromatid of classical cytology as a single DNA protein fibre first coiled to form the 250–300 Å fibre and then folded back longitudinally and transversely. This model assumed that at metaphase, the two sister chromatids are held together at the centromere, until anaphase, by an unreplicated fibre segment of DNA-protein.

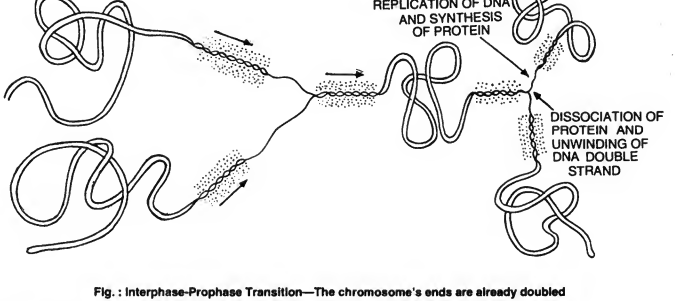


Fig. : Interphase-Prophase Transition—The chromosome's ends are already doubled

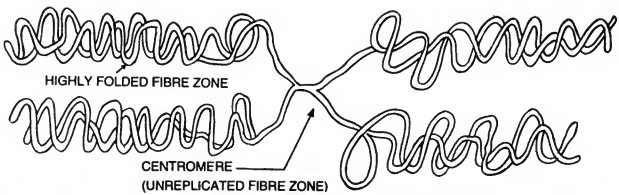
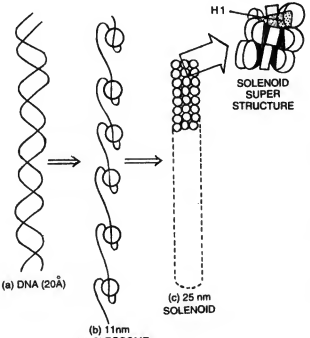


Fig. : Metaphase

Model-III—The radial loop model of **Laemmli (1979)** ventilates chromosome structure by showing the nucleosome organisation. Here each loop is about 85 kilo base.



Implication of Chromosome Structure :

One of the main objectives of cell division is the distribution of chromosomal material into two daughter cells in equivalent amounts. In interphase the chromatin (chromosomal material) is in entangled condition and causes a great problem in its distribution. That is why it must become tightly packed and shortened in order for the chromosomes to move and to divide during mitosis and meiosis. The package of chromatin into chromosome ensures its distribution in equivalent amounts.

Chromatin :

The deoxyribonucleo histone in chromosomes is referred to as **chromatin**. It stains with certain dyes and for this reason it is known as chromatin. In 1974 Roger Kornberg pointed out that chromatin structure is a repeating unit of histones and DNA.

Ultrastructure of Chromatin :

Electron microscopy has revealed that the chromatin structure resembles beads on a string. These beads are made up of a octamer of histone protein. Four types of histones, *viz.*, H 2A, H2B, H3 and H4 are present in duplicate molecule. This octamer with 146 base pairs of DNA form the nucleosome core particle. When this core particle is with '**plugging protein**' (actually the histone 1 or H1 protein) in which 166 base pairs of DNA found and is known as **chromatosome**. This chromatosome with 200 base pairs of DNA (including linker DNA) is known as **nucleosome**.

The nucleosome is a flat disc-shaped particle, 11 nm in diameter and 5·7 nm in height and made up of four types of histones in duplicate molecule. The DNA makes $1\frac{3}{4}$ th turns around the histone octamers and these two turns are sealed off by an H1 molecule (plugging protein). It is interesting that, if the chromatin containing H1 is spread a typical zigzag pattern is produced. When nucleosomes are in close apposition in the 10 nm filaments, the packing of DNA is about 5–7 folds.

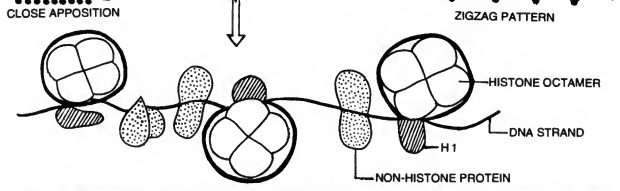
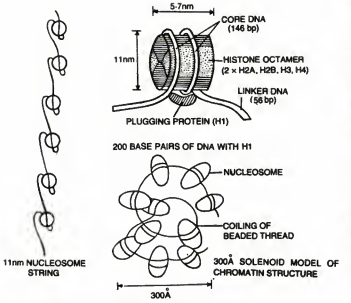


Fig. : Nucleosome Organisation (Adapted from. The cell —A molecular Approach by Cooper, G. M., 1997)



Chemical Composition of Chromatin :

Chromatin is composed of **DNA** and **Chromosomal proteins**. The chromosomal proteins are of two types—**basic proteins** and **acidic proteins (non-histone chromosomal proteins** or **residual proteins)**.

(A) **Basic Proteins**—Basic proteins carry a relatively high proportion of the two basic amino acids—lysine and arginine. These basic proteins found in chromatin are again of two types—(i) **Histones** and (ii) **Protamines**.

(i) **Histones**—Groups of basic proteins which are involved in the coiling of DNA in chromosomes and in the regulation of gene activity, are called **histone proteins**. Five major types of histones are present in most chromatins, each type differing in its relative content of arginine and lysine, *viz.*, H1, H2A, H2B, H3 and H4. (details in the following table).

Histones play vital roles and occupy key position atleast in maintaining chromatin structural integrity and in coiling and uncoiling of chromosomes during the cell cycle. They are also associated with heterochromatinization and genetic repression.

(ii) **Protamines**—These are another class of basic proteins found in the chromatin of the sperms of many invertebrates, fish and some birds. They have molecular weight of about 4000 D (D = dalton; 1D = approximately the mass of a hydrogen atom, *i.e.*, $1{\cdot}66 \times 10^{-24}$ g) and are very rich in arginine.

(B) **Non-histone Chromosomal Proteins (Acidic or Residual Proteins)**—Protein constituents of chromatin other than the histone type are included in this category. These proteins are also called **chromosomine**. Nucleosomes are also associated with non-histones. Ubiquitin, high mobility group proteins (HMG1 and HMG2) etc. are non-histone proteins. From a functional point of view the non-histone chromosomal proteins include polymerases (*e.g.*, DNA polymerase, RNA polymerase), nucleases (DNase, RNase) etc.

The other major component of chromatin is **DNA**. DNA is a nucleic acid occur in chromatin of every living cells. They are not only responsible for storage and transmission of genetic information but also translate this information for a precise synthesis of proteins characteristics of individual cell. DNA is a polymer composed of repeating units called **nucleotides**. A nucleotide is made-up of following three substances—

(a) **Nitrogenous base**
(b) **A deoxyribose sugar**
(c) **A phosphate group**

The four main nitrogenous bases found in DNA are **Adenine (A), Cytosine (C), Guanine (G)** and **Thymine (T)**. Adenine and Guanine are derived from the parent molecule **purine**. The other bases (cytosine and thymine) are derived from the parent molecule **pyrimidine**.

The pentose sugar **deoxyribose** lacks the oxygen at the carbon-2 position and simply has a hydrogen (H).

The bases and sugars in DNA are joined together into units called **nucleosides**. The names of the nucleosides derived from the corresponding bases.

Base	Nucleoside	Nucleotide	Abbreviation
Adenine (A)	d Adenosine	Adenylic acid	d AMP
Guanine (G)	d Guanosine	Guanylic acid	d GMP
Cytosine (C)	d Cytidine	Cytidylic acid	d CMP
Thymine (T)	d Thymidine	Thymidylic acid	d TMP
'*d*' indicates the deoxy-form of sugar			

The subunits of DNA are nucleotides, which are nucleoside with a phosphate group attached through a phospho-ester bond. An ester is an organic compound formed from an alcohol and acid. In case of a nucleotide, the alcohol group is the 5′ hydroxyl of the sugar and the acid is phosphoric acid, for which the ester is called a

Characterization of the Histone Fractions (from Rabbit and Bovine Histones)

Class	Fraction	Molecular Weight (dalton-D)	Lysine + Arginine percentage	Number of Amino-Acid	Function
1. Lysine rich	H1	22,500 D	30·8	244	Acts as plugging protein
2. Slightly lysine rich	H2A	13,960 D	20·2	129	Organise the Octamer
	H2B	13,774 D	22·4	125	
3. Arginine rich (also glycine rich)	H3	15,273 D	22·9	135	
	H4	11,236 D	24·5	102	

phosphoester. During the synthesis of DNA, deoxyadenosine triphosphate (d ATP) is incorporated into DNA and two phosphorus atoms are removed leaving deoxyadenosine 5′ monophosphate (d AMP) in the nucleotide chain. The other three nucleotides in DNA (d CMP, d GMP, dTMP) have analogous structures and names. The nucleotides in DNA are joined together by **phosphodiester bonds.**

Based on the X-ray picture of DNA by M. H. F. Wilkins, R. Franklin and coworkers, J. D. Watson and F. H. C. Crick (1953) proposed a model for DNA structure. The DNA molecule is double helical, with sugar-phosphate backbones on the outside and base pairs on the inside. The two helices are held together by establishing hydrogen bonds in between the two opposite helix base pairs. The bases pair in a specific way : A with T and G with C. The spacing between base pair (vertical rise/bp) is 3·4 Å and the overall helix repeat distance (vertical rise/turn) is about 34Å, meaning that there are about 10 base pairs per turn of the helix. The two strands are antiparallel and the helix is a right-handed one.

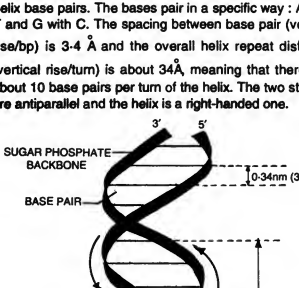


Fig. : The DNA Double Helix

Apart from the presence of proteins and DNA as the chemical constituents of chromatin some metallic ions may also be present. Ca^{2+}, Mg^{2+} apparently function in the maintenance of chromatin structure. On the basis of staining reactions the presence of lipid in the chromatin was also reported.

Euchromatin and Heterochromatin :

The extent of chromatin condensation varies during the life cycle of the cell. In interphase cells, most of the chromatin is relatively decondenced and distributed throughout the nucleus. During this period of the cell cycle, genes are transcribed and the DNA is replicated in preparation for cell division. This type of chromatin is called **euchromatin.** Most of the euchromatin in interphase nuclei appears to be in the form of 30 nm fibres, organised into large loops containing approximately 50–100 Kb (kilo base) of DNA.

In contrast to euchromatin about 10% of the interphase chromatin is in very highly condensed state that resembles the chromatin of cells undergo mitosis. This type of chromatin is called **heterochromatin.** Heterochromatin is transcriptionally inactive and contains highly repeated DNA sequences.

Euchromatin	Heterochromatin
1. Remain condensed during the divisional phase.	1. Remain condensed during interphase and early prophase.
2. Remain decondensed during interphase.	2. Remain decondensed during divisional phase.
3. Stained deeply during the divisional phase.	3. During interphase.
4. It contains genes.	4. It is usually devoid of genes.
5. It constitutes major part of the genome.	5. It constitutes a fraction of the genome.
6. Chromosomal parts except telomeres, primary and secondary constrictions are euchromatic in nature.	6. Telomeres, primary and secondary constrictions are heterochromatic in nature. In mammalian females an entire X-chromosome is heterochromatic. This is called **Barr body**.

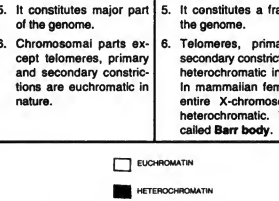


Fig. : Interphase Nucleus of Human Female

Again, on the basis of genetic expression, ontogeny and chemical composition, heterochromatin has been classified into two distinct types : **facultative (= optional) heterochromatin** and **constitutive (= component, forming the part of a whole) heterochromatin.** And sometimes another type, **condensed heterochromatin,** is also seen as evidenced by some authors (Frenster **et al.** 1963, 69 ; Goodenough and Levine, 1974).

Facultative heterochromatin is a chromatin which is condensed in one of the two homologous chromosomes on in one haploid set of chromosomes but not in the others, *e.g.*, in Mealy bug (**Planococcus citri**), a coccid

insect, the entire parental set of male insects are facultatively heterochromatinized (Ref. Brown and Nur, 1964).

Constitutive heterochromatin is a chromatin which is found consistently in the same regions of both homologous chromosomes or chromosomal segments, which remains condensed throughout the cell cycle. It is biochemically different from euchromatin, being largely composed of highly repeated DNA sequences, *e.g.*, centromeric and telomeric regions of normal chromosome at mitosis; as well as in prochromosomes in the interphase condition.

Condensed heterochromatin is a chromatin which is also deeply stained due to tight packing of the chromatin, can be found in many interphase nuclei. This type of heterochromatin is of a similar class of facultative heterochromatin and the state is often reversible. Different types of leucocytes, mammalian sperm cells, generative nuclei of angiospermous pollen tube etc. contain condensed heterochromatin.

OBJECTIVE QUESTIONS

1. In which phase of mitosis the chromosomes are arranged around the equator of the spindle ?
   (A) Anaphase (B) Metaphase
   (C) Telophase (D) Prophase
2. Chromosome number is halved in meiosis during—
   (A) Anaphase I
   (B) Metaphase I
   (C) Metaphase II
   (D) Telophase I
3. Structure present over the chromosome is—
   (A) Centrosome
   (B) Golgi complex
   (C) Nucleolus
   (D) Centromere
4. Chromosomes whose arms are equal are termed as—
   (A) Acentric
   (B) Acrocentric
   (C) Metacentric
   (D) Concentric
5. Minimum number of chromosomes are found in—
   (A) Helianthus
   (B) Haplopappus
   (C) Ophioglossum
   (D) Riccia
6. Chromosomes contain—
   (A) Only protein
   (B) Only DNA
   (C) DNA and RNA
   (D) RNA, DNA and protein
7. Terminal end of chromosome is called—
   (A) Centromere
   (B) Chromomere
   (C) Chromonemata
   (D) Telomere
8. Duplication of chromosomes takes place in—
   (A) S-phase
   (B) G_1-phase
   (C) G_2-phase
   (D) All of the above
9. Strands of DNA are bonded by—
   (A) Oxygen (B) Nitrogen
   (C) Hydrogen (D) Carbon
10. The number of hydrogen bonds that bound cytosine and guanine is—
    (A) 1 (B) 2
    (C) 3 (D) 4
11. In which stage chromosome is longer ?
    (A) Leptotene
    (B) Zygotene
    (C) Pachytene
    (D) Diakinesis
12. The term chromosome was coined by—
    (A) Hofmeister
    (B) Altmann
    (C) Strasburger
    (D) Waldeyer
13. Basic structure of chromatin is composed of—
    (A) DNA wrapped around histones
    (B) Non-histone proteins wrapped around DNA
    (C) RNA wrapped around histones
    (D) Histone proteins wrapped around DNA
14. The core particle of nucleosome is composed of how many histones ?
    (A) Four (B) Five
    (C) Three (D) Six
15. During prophase the chromosomal material becomes visible as very thin filament, which are called—
    (A) Chromonemata
    (B) Chromomere
    (C) Telomere
    (D) Satellite

ANSWERS

1. (B) 2. (A) 3. (D) 4. (C) 5. (B)
6. (D) 7. (D) 8. (B) 9. (C) 10. (C)
11. (A) 12. (D) 13. (D) 14. (A) 15. (A)

●●●

(Continued from Page 1795)

tend to have J-shaped growth curves until some environmental change causes them to decline, usually within a short time. From an evolutionary point of view, such species have undergone selection to maximize their rate of natural increase and for this reason, they are said to be *r*-strategists.

10. The uterine cycle occurs concurrently with the ovarian cycle. In the first half of these cycles (days 1–13, before ovulation), the anterior pituitary produces FSH and the follicle produces estrogen. Estrogen causes the uterine lining to increase in thickness.

15. Dragonfly is an insect. A tracheal tube from each spiracle in insects. It branches into fine tracheoles, which penetrate the muscles and organs. Thus, oxygen directly diffuses in the muscles and organs.

●●●

Topic on Botany

LICHENS

—AMIT KUMAR JHA

Lichens are autotrophic, superficial, slow growing, long lived perennial composite (dual) aerial plants of lowly organisation possessing symbiotic association between an alga (called as **phycobiont,** GK. phycos = seaweed *i.e.*, alga; bios = life) and a fungus called as **mycobiont,** GK. mycos = fungus; bios = life, in which alga supplies synthesized food (by photosynthesis) to the fungus (biotrophic) and the fungus gives protection, water and mineral salts to the alga (the phenomenon is called **heiotism** or mast slave relationship). There are about 400 genera and 15,000 species of lichens.

Lichens were first discovered by **Tuisane** in 1852 and a few years later, **De Bary** studies the two constituent organisms in detail and called the relationship of algae and fungi as **symbiosis**. The term lichen was coined by **Theophrastus** (371–284 B.C.). **Acharius** laid the foundation of the systematic study of lichens by dividing cryptogams into six families including lichens. The study of lichen is called **lichenology**. The dual nature of lichens was established by **Schwendener**, otherwise lichens were thought to be bryophytes or individual plant. **Bonnier** successfully synthesized a lichen in the years 1886–89, by growing fungal spores with algae. **Reinke** (1872) called the relationship of algae and fungi in lichens as a sort of consortium (marriage). **Ahmajian** (1963) stated that the fungus is a controlled parasite over the alga (slave).

Habit :

The lichens are cosmopolitan, commonly occur as greyish-green, greenish-white or brightly coloured incrustations, one to several cm in diameter. Sometimes, they hang in shaggy tufts, a few to several cm long, from the branches of shrubs and trees.

Habitat :

On the basis of their habitats they have been grouped into the following categories—

(a) **Corticolous**—Lichens growing on old walls and tree trunks, *e.g.*, *Parmelia*, *Usnea*.

(b) **Saxicolous**—Lichens growing on stones and rocks, *e.g.*, *Xanthoria*, *Pornia*.

(c) **Terricolous**—Lichens growing on soil surfaces, *e.g.*, *Cladonia*, *Floerkeana*.

The lichens may also occur in fresh water *e.g.*, Hymenelia lawstris or in marine water, *e.g.*, *Caloplaea marina*.

Classification

Depending on the nature of the fungi, lichens have been classified into three main groups (by **Alexopoulos** and **Mims** in 1979)–

(A) Ascolichens :

In Ascolichens the fungi are members of Ascomycetes (sac fungi) reproducing by means of ascospores—

They may be further divided into—

(a) **Discolichens**—When the fungi in them are members of discomycetes (cup fungi), producing open, cup or saucer shaped apothecia (the fruiting body). They are found in temperate area, *e.g.*, *Graphis*, *Parmelia*, *Usnea*.

(b) **Pyrenolichens**—When the fungi in them are members of pyrenomycetes (flask fungi), producing closed, flask shaped perithecia (the fruiting body) with an apical opening (ostiole), *e.g.*, *Dermatocarpon*, *Cladonia*.

(B) Basidiolichens :

In Basidiolichens, the fungi are members of Basidiomycetes. There are only three genera of Basidiolichens, *viz.*, *Cora*, *Corella* and *Dictyonema*. The best known genus is *Cora* (bracket fungi).

(C) Deuterolichens :

In Deuterolichens, the fungi are members of Deuteromycetes (fungi imperfecti). In which sexual stage is not known and they reproduce by conidia, along with some other types of spores.

On the basis of algal partners, lichens have been grouped into three main groups—

(A) Chlorophycophilous :

They are associated with green algae, *e.g.*, *Chlorella*, *Palmella*, *Protococcus*, etc.

(B) Cyanophycophilous :

They are associated with cyanobacteria, *e.g.*, *Chroococcus*, *Nostoc*, *Sytonema*, etc.,

(C) Diphycophilous :

They are associated with both green and blue green algae.

Morphology (Thallus)

The association of fungal and algal component forming lichen thallus is considered to be **mutualistic symbiosis**. The fungal partner of lichen is dominant forming 95–99% of total thallus and is responsible for reproduction. The algal part of lichen is 75% chlorophyceae mostly. 26 algal genera (17 green algae, 8 blue green algae and 1 yellow green algae) are reported in lichen thalli.

The lichen thalli follow three different patterns of growth (**Hue–1899**) in different genera as follows—

(A) Crustose lichens :

These form, hard, granular crusts and adhere very tenaciously to rocks, barks of shrubs, trees and certain soils. *e.g.*, *Graphis*, *Lecanora*, *Haematomma*, *Rhizocarpon*.

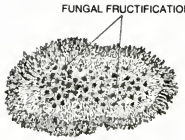


Fig. : Graphis

(B) Foliose lichens :

These form definite, flattened leaf like thalli with lobed margins and adhere to walls, tree trunks, rocks and the ground by **hairy rhizoid**, like structures called **rhizines**, *e.g., Parmelia, Peltigera, Corapavonia.*

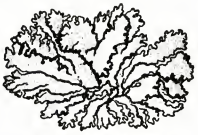


Fig. : Foliose in Parmelia

(C) Fruticose lichens :

These form much branched, shrub like bodies which remain attach by their narrow basal portion only (by a variety of structure such as **rhizinose strands, rhizines, holdfast, haptera, hypothallus,** etc.)

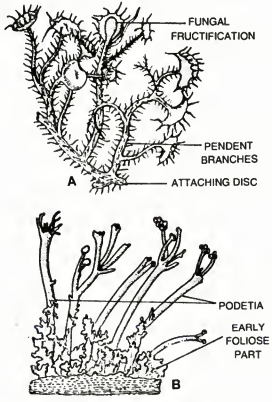


Fig. : (A) Usnea, (B) Cladonia

In *Cladonia* the plant body is distinguishable into a prostrate, leafy, lobed primary thallus from which arise branched or unbranched upright secondary thalli called podetia (sing.–podetium). It is sometimes, provided with a cup like structure called scyphus at the tip.

Recently, a fourth category of lichens called **Leprose** has been also discovered in which some fungal hyphae surround one or more algal cells, *e.g., Leprosia.*

Anatomy

Internally on the basis of distribution of algal components, the lichens have been divided into two categories—

(A) Homoiomerous :

In these forms algal and fungal components are uniformly distributed among fungal hyphae throughout the thallus. Such thalli are also called as **endogenous,** *e.g., Collema, Leptogium,* etc.

(B) Heteromerous :

In these forms algal cells are few and restricted to the layer of hyphae and forms a distinct layer called **gonidial layer,** on the upper side of the thallus. They are also called as **exogenous,** *e.g., Parmelia, Xanthoria,* etc.

Generally a section through the thallus of a foliose and fruticose lichens shows following regions—

(1) **Upper cortex**—The cortex is of two types—

(a) **Paraplectenchymatous**—They have randomly oriented hyphae.

(b) **Prosoplectenchymatous**—They have hyphae oriented in a specific direction.

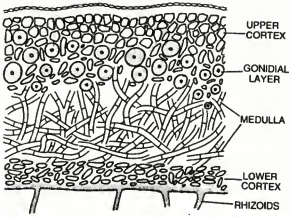


Fig. : A section through the thallus of a foliose lichen

(2) **Lower cortex**—It is made up of closely packed hyphae. Some of the hyphae also act as rhizines (rhizoids).

However, in *Usnea* there is a **central chondroid axis** made up of thick walled, closely packed fungal hyphae.

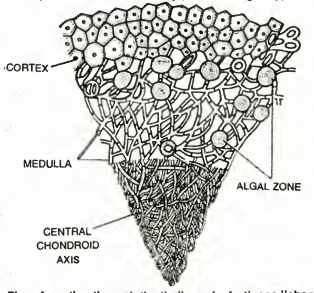


Fig. : A section through the thallus of a fruticose lichen

(3) **Algal zone**—It lies below the upper cortex (usually called the **gonidial layer**).

(4) **Medulla**—The zone following the algal layer, consisting of only loose mass of hyphae in the central region.

Specialized structures :

Some specialized structures like breathing pores, cyphellae, cephalodia, isidia and soredia are associated with lichen thalli.

On the upper surface of some lichens (foliose lichens), fungal hyphae are loosely arranged, to form pores, which help in aeration, so known as **breathing pores,** *e.g., Parmelia.*

Cyphellae are small, almost circular depressions present on the lower side of the thallus. They are meant for exchange of gases, *e.g., Sticta.*

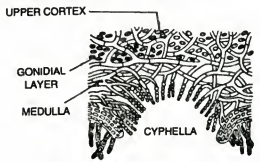


Fig. : V.S. of thalli through cyphella

Structures like cephalodia, isidia and soredi, help in vegetative reproduction. So, these structures have been discussed later.

Points to Remember

- **Morrison (1699)** called lichens as **musco-fungus.**
- **D.D. Awasthi** is a famous lichenologist of India.
- Lichens having two algal and one fungal partners are called as **diphycophilous.**
- **Trebouxia,** an unicellular green alga, is the commonest algal component of lichens.
- Those lichens which fix atmospheric nitrogen are called **'azotodesmic lichens'.**
- Cyphellae without any cortical border are called as **pseudocyphellae.**
- Common name of some lichens—
  - (a) *Cladonia*—Reindeer moss or British soldiers
  - (b) *Lecanora*—Manna or Bread of heaven
  - (c) *Parmelia*—Rock flower
  - (d) *Cetraria*—Iceland moss
  - (e) Peltigera—Dog lichen
  - (f) *Lobaria*—Lung wort
  - (g) *Letharia*—Wolf moss
  - (h) *Endocarpon*—Stone mushroom
  - (i) *Usnea*—Old man's beard

Reproduction

1. Vegetative Reproduction :

The lichens generally reproduce vegetatively by the following structures—

(A) **Soredia**—These are microscopic, granular bodies occurring in large numbers on the upper surface of the thallus as a greyish coating of powder. Each soredium consists of both algal and fungal components formed in a postule like structure called as **sorallum.** *e.g., Physia, Parmelia, Usnea, Cladonia etc.*

The soredia are easily dispersed by wind or rain and under appropriate conditions soredium forms a new thallus.

(B) **Isidia**—These are coral like, simple or branched outgrowths present on the upper surface of the thallus.

These are primarily meant for increasing surface area and photosynthetic activity.

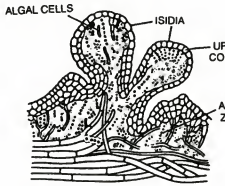


Fig. : V.S. of thalli through isidium

(C) **Cephalodia**—These are gall like, dark swelling on the upper surface of the thallus, sometimes internally as well.

They are distinguishable into cortex and medulla. The cephalodia are meant for retaining moisture, *e.g., Peltigera.*

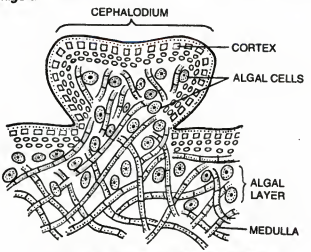


Fig. : V.S. of thalli through cephalodium

(D) **Oidia**—In a few lichens, the hyphae may break up into short segments called oidia. An oidium germinates like a spore, producing normal hyphae.

(E) **Rejuvination**—Lichens like *Cladonia* show this unique phenomenon. The older parts of the thalius dies whereas the young branches continue to grow.

(F) **Fragmentation**—In many lichens, the thallus may be divided into long or short fragments. Each fragment may grow to the size of the independent thallus, *e.g., Usnea.*

2. Asexual Reproduction :

The **Ascolichens** reproduce asexually by forming spores of fungal origin. On germination, each spore sends out hyphae in different directions. If any of them happens to come in contact with the requisite alga, it branches freely and covers up the algal cell. The combined body then grow into a lichen thallus.

Many lichens (*e.g., Physcia*), produce small spore like bodies in large numbers within a flask-shaped cavity, called the **pycnidium**. The spores are called **pycnidiospores** (or pycnospores) which constitute the lichen on coming in contact with suitable algal component.

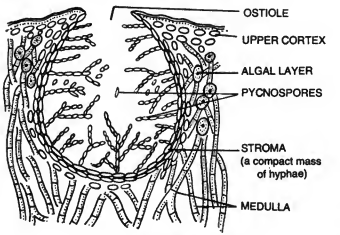


Fig. : V.S. through pycnidium

In some species, the so-called pycnidia behave as **male sex organ (spermogonia)** and the so-called pycnidiospores behave as male cells **(spermatia)**.

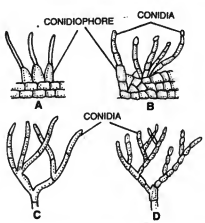


Fig. : A-D. Different forms of conidia or conidiophores

Basidiolichens (*e.g.*, Cora) reproduce asexually by means of **basidiospores**.

3. Sexual Reproduction :

This has been observed in certain Ascolichens, as in *Collema*, it is entirely the job of fungal partner only. It is of **oogamous** type *i.e.*, by well developed sex organs.

The female sex organ is a multicellular, stout filament of large cells; known as the **carpogonium**. It consists of a coiled basal portion called the **ascogonium**, lying within the thallus and a tube like upper portion beyond the thallus. The terminal region is somewhat erect and called as **trichogyne**.

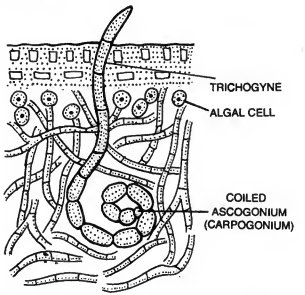


Fig. : V.S. through ascogonium

The male sex organ, the **spermogonium**, is a flask-shaped chamber with an apical opening **(ostiole)** the minute, **non-motile** male cells formed within it are known as the **spermatia**.

Spermatia are very minute and cylindrical. They are liberated through the ostiole in slimy masses to float on the thallus (Figure of a spermatogonium *i.e.*, pycnidium has already given).

Fertilization :

Fertilization occurs when a spermatium comes in contact with the sticky, protruding tip of a trichogyne. Its protoplast migrates into the trichogyne and apparently fuses with the ascogonium nucleus (called plasmogamy).

Several ascogenous hyphae now develop from the basal part of fertilized cell of ascogonium; these hyphae branch freely and develop an **ascus**, always at the end of a branch. This is followed by meiosis and mitosis resulting in the formation of **1-8 ascospores** inside the ascus. Simultaneously, the surrounding hyphae also develop and as a result fruiting body, called **ascocarp** or **ascomata,** is formed. The ascocarp may be an **apothecium** (*e.g., Physcia*) or **perithecium** (*e.g., Acrocordia*).

On the basis of shape of ascocarp, Ascolichens are of two types namely **gymnocarpae** and **pyrenocarpae**.

The fruiting body is internally distinguishable into three zones—

(a) **Thecium**—It is the fertile zone, comprising fertile asci and sterile paraphyses.

(b) **Hypothecium**—It is the zone formed by loosely packed hyphae lying below the thecium.

(c) **Epithecium**—It is the zone formed by the tips of paraphyses projecting beyond the asci.

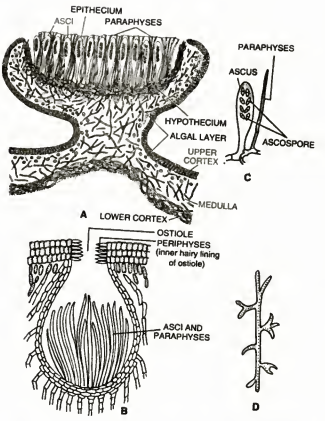
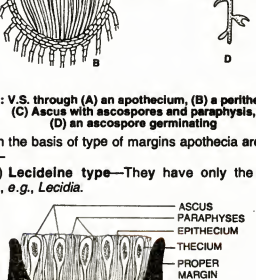


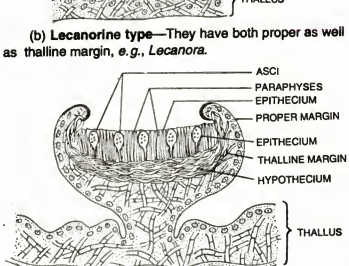
Fig. : V.S. through (A) an apothecium, (B) a perithecium, (C) Ascus with ascospores and paraphysis, (D) an ascospore germinating

On the basis of type of margins apothecia are of two types—

(a) **Lecideine type**—They have only the proper margin, *e.g., Lecidia.*



(b) **Lecanorine type**—They have both proper as well as thalline margin, *e.g., Lecanora.*



The sterile tissue lying in between the asci is sometimes called as **hamathecia**. There are **four types** of hamathecial elements are found in ascocarp—

(i) **Paraphyses**—They are compact mass of cylinder sterile hyphae, arise from the base of the ascocarp and grow vertically upward.

(ii) **Periphyses**—They arise in the ostiolar canal of the ascocarp and protrude out of the ostiole.

(iii) **Paraphysoid**—They are formed by stretching of the tissue of an ascocarp, and

(iv) **Periphysoids**—They arise from the roof of the ascocarp and grow vertically downward.

On liberation, the mature ascospores germinate, producing fungal hyphae, which come in contact with the suitable algae, grow rapidly and eventually produce lichen thalli.

Economic Importance

1. Beneficial Activities :

(A) **Early colonizer**—Lichens are the pioneers of plant growth on base rocks are called first colonizers.

(B) **Soil builder**—The lichens are pioneers of vegetation in a lithosere (succession on rocky surface). They bring about biological weathering of rocks by forming acids such as **carbonic acid, oxalic acid**, etc., which leads to soil formation.

(C) **Food**—Some lichens are a valuable source of food for wild animals and cattle.

(a) *Cladonia rangiferina* growing to a height of about 30 cm, in the arctic regions, serves as food for Reindeer, hence called **'reindeer-moss'**.

(b) *Certaria islandica* is used as food article in iceland (hence called **'Iceland moss'**), Sweden and Norway.

(c) *Lecanora esculenta* is used as food in Israel.

(d) *Enocarpon miniatum* is used as a vegetable in Japan.

(e) *Umblicaria esculenta* is used as food in Japan.

(f) *Parmelia*, generally called **rathapu** in Telgu is used as a spice in curry (curry powder) in South India and it is also used as a food, as well as in making chocolates and pastries.

(g) Species of *Stereocaulon* and *Evernia* are also used as fooder.

Lichenin

The nutritivo value of lichens is due to presence of **'Lichenin'** a carbohydrate allied to starch (true starch and cellulose are not found in lichens).

A lichen takes CO_2 from air and produces lichenin, hence called an **air-purifier**.

(D) **Medicinal uses—**

(a) *Cladonia pyxidata* is used in the treatment of **whooping-cough**.

(b) *Parmelia permata* is used in the treatment of **snake-bite**.

(c) *Parmelia sexatilis* is used in the treatment of **epilepsy**.

(d) *Lobaria purmelia* is used in the treatment of **lung diseases**.

(e) *Evernia* and *Usnea* are used in the treatment of **haemorrhage**.

(f) *Usnea barbata* is used in the treatment of **urinary diseases**.

(g) Some species of *Usnea* and *Cladonia* are used to extract an antibiotic called **usnic acid** which has antibacterial activity and has proved very effective against **tuberculosis** when used in combination with **streptomycin**.

(h) *Peltigera* and Black pepper is used in the treatment of **rabies**.

(i) *Peltigera canina* is used in the treatment of **hydrophobia** and **liver ailments**.

(j) *Cetraria islandica* is used in the treatment of **diabetes** and **respiratory diseases**.

(k) *Rocella montagnei* is used in the treatment of **angina**.

(l) *Cladonia*, *Rocella* and *Evernia* are used in controlling different types of **fevers**.

(m) The protolichesterinic acid obtained from some lichens has **anticarsinogenic properties**.

(E) Industrial uses—

(a) The lichens contain carbohydrates in the form of **lichenin**. Hence, they are used in producing alcohol in countries like Sweden and Russia.

(b) Species of *Evernia*, *Pseudornia*, *Ramalina* contain essential oils and hence they are used in manufacture of soaps and perfumes. Besides, they also contain chemicals like *geraniol*, *napthalene*, etc.

(c) A **red dye** is obtained from *Ochrolechia* species.

(d) A **brown dye** is obtained from *Parmelia* species.

(e) A dye **orchil** is prepared from *Rocella tinctoria*.

(f) Other brilliant colouring dye is, **cud-bear** obtained from lichen species.

(g) **Litmus** used as acid-base indicator is obtained from *Rocella montagnei and Lasallia pustulata*.

(F) Indicator of air pollution—Lichens act as an indicator of air pollution because no lichen can be found in the areas of heavy industrial pollution because lichens are sensitive to SO_2.

(G) N_2 fixation—Lichens having blue green algae are important in **fixing nitrogen.**

(H) Chemicals—Some lichen yield important chemicals. For example—

(i) *Ramalina siliquosa* yield **salzinic acid**.

(ii) *Parmelia subtrudecta* yield **lecanoric acid**.

(iii) *Cladonia crispate* yield **squamatic acid**.

(I) Religious importance—Sweet-scented thalli of lichens like *Evernia*, *Ramalina* are used in the preparation of **'dhup'** and **'hawan samagris'**.

2. Harmful Activities :

(A) Damaging buildings—In humid areas, lichen can grow on window panes, marble and cement damaging the building by their etching activity.

(B) Poisonous—Some lichens are poisonous, such as *Letharia vulpina* due to vulpinic acid, *Cetraria juniperina* due to pinastrinic acid, *Parmelia molliuscula* due to selenium, *Xanthoria parietina* due to beryllium and *Evernia furfuracea* due to chlorine.

OBJECTIVE QUESTIONS

1. The term 'Lichen' was first coined by—
   (A) Linnaeus
   (B) Theophrastus
   (C) Fritsch
   (D) Smith
2. The lichens generally do not contain a mycobiont belonging to—
   (A) Mastigomycotina only
   (B) Mastigo and Zygomycotina
   (C) Deuteromycotina
   (D) All of these
3. Which food is used by fungal partner made by algal partner in a lichen ?
   (A) Starch (B) Sugar
   (C) Mannitol (D) Glycogen
4. The uncommon type of propagules which help in the vegetative propagation of lichens are—
   (A) Isidia and soredia
   (B) Isidia and phyllidia
   (C) Phyllidia and blastidia
   (D) Soridia and blastidia
5. The term ascomata in lichens is applied to—
   (A) Ascogenous hyphae
   (B) Ascus zone
   (C) Ascus mother cell
   (D) Ascocarp
6. Hyphal outgrowth arising from the lower cortex of the thallus of foliose lichens are called as—
   (A) Mycelium (B) Rhizines
   (C) Haustoria (D) Rhizoids
7. The edible fruiting bodies which are underground are called—
   (A) Truffles (B) Puff balls
   (C) Ascocarp (D) Basidiocarp
8. Which of the following structure of lichen is diphycophilous ?
   (A) Soralium
   (B) Cephalodium
   (C) Soredium
   (D) Isidium
9. Biological weathering of rock is initially brought about lichens that are followed by foliose—
   (A) Fruticose (B) Thallose
   (C) Leprose (D) Crustose
10. Which of the following is a poisonous lichen ?
    (A) *Letharia vulpina*
    (B) *Cetraria juniperina*
    (C) Both A and B
    (D) *Lecanora esculenta*
11. Orchil, a blue coloured dye, is prepared from—
    (A) *Rocella* (B) *Ramalina*
    (C) *Cladonia* (D) *Usnea*
12. The common lichens of tundra region (eaten by musk ox or Caribou and Reindeer) are—

(Continued on Page 1828)

BOTANY

(Based on Memory)

1. A cross between F_1 hybrid and a recessive parent gives the ratio of—
   (A) 3 : 1 (B) 1 : 1
   (C) 2 : 1 (D) 4 : 1
2. Photorespiration is characteristic of—
   (A) C_3-plants
   (B) C_4-plants
   (C) CAM plants
   (D) None of the above
3. The replication of nuclear DNA occurs in—
   (A) G_1-phase (B) G_2-phase
   (C) S-phase (D) M-phase
4. In plants auxin synthesis occurs in—
   (A) Cortex
   (B) Phloem cells
   (C) Root and shoot tips
   (D) Xylem cells
5. Maximum transpiration occurs in—
   (A) Mesophytic plants
   (B) Hydrophytic plants
   (C) Xerophytic plants
   (D) Algal cells
6. Nuclear material without nuclear membrane is observed in—
   (A) Bacteria and green algae
   (B) Cyanobacteria and red algae
   (C) Bacteria and Cyanobacteria
   (D) Mycoplasmas and green algae
7. Pachytene occurs during—
   (A) Meiosis
   (B) Mitosis
   (C) Growth of a cell
   (D) Formation of endosperm
8. Chiasmata formation occurs during—
   (A) Diplotene
   (B) Leptotene
   (C) Pachytene
   (D) Diakinesis
9. The strength and rigidity of a cell wall is due to the substance known as—
   (A) Suberin (B) Cellulose
   (C) Lignin (D) Pectin
10. Plant cells lack—
    (A) Spindle fibres
    (B) Centrioles
    (C) Asters
    (D) Centrioles and asters
11. Nitrogen is an important constituent of—
    (A) Protein
    (B) Lipids
    (C) Carbohydrates
    (D) Polyphosphates
12. Lysosomes are so called because they contain—
    (A) Carboxylating enzymes
    (B) Respiratory enzymes
    (C) Oxidizing enzymes
    (D) Digestive enzymes
13. Study of fungus is called—
    (A) Mycology
    (B) Phycology
    (C) Malacology
    (D) Palynology
14. In mitosis the duplication of chromosomes occurs during—
    (A) Early prophase
    (B) Late prophase
    (C) Interphase
    (D) Late telophase
15. The smallest living cells with cell wall are—
    (A) Viroids
    (B) Algae
    (C) Bacteria
    (D) Mycoplasma
16. Mitochondria are non-existent in—
    (A) Red algae
    (B) Bacteria
    (C) Green algae
    (D) Brown algae
17. When a gene exists in more than one form, the different forms are called—
    (A) Heterozygous
    (B) Complementary genes
    (C) Genotypes
    (D) Alleles
18. The site of protein synthesis in plants is the—
    (A) Chloroplast
    (B) Ribosomes
    (C) Pyrenoids
    (D) Mitochondria
19. Karyokinesis differ from cytokinesis because it involves—
    (A) Division of cytoplasm
    (B) Division of the nucleus and cytoplasm
    (C) Division of the nucleus
    (D) Division of the cell
20. Lignified cell wall is the characteristic feature of—
    (A) Phloem cells
    (B) Epidermal cells
    (C) Cambial cells
    (D) Xylem cells
21. Biological oxidation in Krebs cycle involves—
    (A) N_2 (B) CO_2
    (C) O_2 (D) SO_2
22. The chloroplasts of algae usually lack—
    (A) Grana
    (B) Pigments
    (C) Quantasomes
    (D) Lamellae
23. Who of the following proposed photoperiodism ?
    (A) Garner and Allard
    (B) Darwin
    (C) Lysenko
    (D) Arnon
24. The arrangement of three bases in the genetic code signifies a specific—
    (A) Protein (B) Amino acid
    (C) Plasmid (D) Nucleic acid
25. Each couple should produce only two children which will help in—
    (A) Checking pollution
    (B) Stabilising the ecosystem
    (C) Fertility of soil
    (D) Improving food-web

26. The ripening of fruits can be hastend by treatment with—
(A) Gibberellic acid
(B) Indole-acetic acid
(C) Florigen
(D) Ethylene gas

27. The nucleoplasm is continuous with the cytoplasm of the cell through—
(A) Centriole
(B) Endoplasmic reticulum
(C) Nuclear pores
(D) Golgi apparatus

28. Oogamous sexual reproduction signifies—
(A) Fusion of similar motile gametes
(B) Fusion of dissimilar motile gametes
(C) Fusion of motile and a non-motile gametes
(D) Fusion of similar non-motile gametes

29. The process involved in the RNA formation on the DNA template is—
(A) Translation
(B) Transduction
(C) Transcription
(D) Transformation

30. The functional unit in the synthesis of protein is—
(A) Peroxisome
(B) Dictyosome
(C) Lysosome
(D) Polysome

31. In rapidly dividing cells, endoplasmic reticulum is—
(A) Poorly developed
(B) Highly developed
(C) Absent
(D) Non-functional

32. During the first metaphase of meiosis the centromeres—
(A) Undergo division
(B) Do not divide
(C) Divide but do not separate
(D) Are not identical

33. Light energy is converted into chemical energy in the presence of—
(A) Pyrenoids
(B) Chloroplasts
(C) Ribosomes
(D) Mesosomes

34. The replication of centrioles occurs during—
(A) Early prophase
(B) Late prophase
(C) Late telophase
(D) Interphase

35. The bicollateral vascular bundle is the characteristic feature of plants belonging to the family—
(A) Cruciferae
(B) Liliaceae
(C) Cucurbitaceae
(D) Malvaceae

36. The major role of phosphorus in plant metabolism is—
(A) To generate metabolic energy
(B) To evolve oxygen during photosynthesis
(C) To evolve carbon dioxide during respiration
(D) To create anaerobic conditions

37. Phragmoplast is precursor of—
(A) Cell plate
(B) Chloroplast
(C) Chromoplast
(D) Colourless plastid

38. According to the 'Unit membrane model' the thickness of the cell membrane is about—
(A) 200 nm (B) 7·5 nm
(C) 150 nm (D) 1·0 nm

39. The colour of rose petals is due to water soluble pigments present in the—
(A) Cytoplasm
(B) Nucleus
(C) Intercellular spaces
(D) Vacuoles

40. The genes are responsible for growth and differentiation in an organism through regulation of—
(A) Translocation
(B) Transformation
(C) Transduction and Translation
(D) Translation and Transcription

41. The male cone of *Pinus* is formed of—
(A) Anthers
(B) Megasporophylls
(C) Ligules
(D) Microsporophylls

42. The function of nucleolus is the synthesis of—
(A) DNA (B) *m*-RNA
(C) *r*-RNA (D) *t*-RNA

43. Female gametophyte of angiospermic plants is represented by—
(A) Oospore (B) Egg
(C) Carpel (D) Pollengrain

44. Endospermic nucleus is usually—
(A) Haploid (B) Diploid
(C) Triploid (D) Tetraploid

45. Cell division in blue-green algae is more or less similar to that in—
(A) Red algae
(B) Green algae
(C) Brown algae
(D) Bacteria

46. Photosynthates are transported to other parts of higher plants through—
(A) Cambial cells
(B) Pith cells
(C) Xylem cells
(D) Phloem cells

47. Experimental demonstration of the semi-conservative mode of DNA replication was given by—
(A) Watson and Crick
(B) Bawden and Palison
(C) Meselson and Stahl
(D) Huberman and Riggs

48. Mitochondria supply most of the necessary biological energy by—
(A) Breaking down of sugar
(B) Oxidising substrates of TCA cycle
(C) Reducing NADP
(D) Breaking down of protein

49. The internal layer joining the primary walls of the two adjacent cells is known as—
(A) Plasmodesmata
(B) Middle lamella
(C) Periderm
(D) Casparian strip

50. Genetic transfer through viruses is called—
(A) Sexduction
(B) Transduction

(C) Conjugation
(D) Transformation

51. Oxidative phosphorylation occurs during the process of—
(A) Protein synthesis
(B) N_2-fixation
(C) Respiration
(D) Transpiration

52. The pyramid of energy is always–
(A) Inverted
(B) Upright
(C) Both upright and inverted
(D) Inverted in forest ecosystem

53. Who proposed the binomial nomenclature system ?
(A) Whittaker
(B) Mendel
(C) Carl Linnaeus
(D) Tippo

54. Cheese and yogurt are products of the process—
(A) Distillation
(B) Pasteurization
(C) Fermentation
(D) Dehydration

55. From which part of Ephedra plant, the drug, 'Ephedrine' is obtained ?
(A) Root (B) Stem
(C) Leaves (D) Flowers

56. The eucaryotic chromosomes are made up of—
(A) DNA
(B) RNA
(C) DNA and proteins
(D) DNA and lipids

57. How many pairs of contrasting characters in pea pod were chosen by Mendel ?
(A) 2 (B) 3
(C) 4 (D) 7

58. If a homozygous dominant red-flowered plant is crossed with a homozygous recessive white flowered plant, the offspring would be—
(A) Half red-flowered
(B) Half white-flowered
(C) All red-flowered
(D) Half pink-flowered

59. Most important causative pollutant of soil may be—
(A) Plastic
(B) Iron junks
(C) Detergents
(D) Glass junks

60. Desired improved variety of economically useful crops are raised by—
(A) Natural selection
(B) Hybridization
(C) Mutation
(D) Biofertilizer

61. When an ovary develops into a fruit without fertilization it is called—
(A) Porogamy
(B) Apospory
(C) Apogamy
(D) Parthenocarpy

62. Desert can be converted into greenland by—
(A) Oxylophytes
(B) Psammophytes
(C) Halophytes
(D) Tropical trees

63. Improvement of crops by preserving germplasm in frozen state is called—
(A) Cryopreservation
(B) Cold storage preservation
(C) Vernalization
(D) In situ preservation

64. Which one of the following life cycles is associated with Mucor ?
(A) Haplontic
(B) Diplontic
(C) Isomorphic
(D) Heteromorphic

65. Reproducing new plants by cells instead of seeds is known as—
(A) Biofertilizer
(B) Tissue culture
(C) Mutation
(D) Antibiotics

66. In which cell types of Funaria, reduction division takes place ?
(A) Antheridial cells
(B) Archegonial cells
(C) Zygotic cells
(D) Spore mother cells

67. Heroin is obtained from the plant of—
(A) Poppy
(B) Tobacco
(C) Datura
(D) Cannabis sps

68. Which cultivation method is most popular in Madhya Pradesh to cultivate rice ?
(A) Intensive (B) Dry
(C) Wet (D) Tillage

69. The Tobacco mosaic virus was crystallised for the first time by—
(A) W. N. Stanley
(B) Louis Pasteur
(C) Edward Jenner
(D) Andre Lwoff

70. The bacterial ribosomes are of—
(A) 50 s-type (B) 70 s-type
(C) 30 s-type (D) 80 s-type

71. L. P. G. cooking gas is—
(A) Low pressure gas
(B) Bio gas
(C) Fossil fuel
(D) Low price gas

72. The pioneer country in the production of fuel-alcohol is—
(A) Saudi Arabia
(B) Iran, Iraq
(C) Brazil
(D) Japan

73. Enzymes are the polymers of—
(A) Hexose carbon
(B) Fatty acids
(C) Aminoacids
(D) Inorganic phosphate

74. A quicker regeneration of leaves of grasses will occur by—
(A) Clipping (B) Cutting
(C) Grazing (D) Irrigation

75. Which of the following word is related to *Homo sapiens* ?
(A) Herbivorous
(B) Carnivorous
(C) Autotroph
(D) Omnivorous

76. A plant raised from a single germinating pollen grain under cultural conditions is called a—
(A) Haploid plant
(B) Diploid plant
(C) Tetraploid plant
(D) Polyploid plant

77. Modified antibiotics are manufactured by the technique of—
(A) Ultrafiltration
(B) Ultra centrifuge
(C) Vernalization
(D) Genetic engineering

78. Photochemical smog is related to the pollution of—
(A) Soil (B) Water
(C) Noise (D) Air

79. The nitrogenous bases in DNA are—
(A) AUGC (B) UTGC
(C) ATGC (D) ATUC

80. Stramonium drug is obtained from the plant species of—
(A) Ocimum (B) Rauwolfia
(C) Datura (D) Asphodelus

81. Checking of re-radiating heat by atmospheric dust, water vapours, ozone, CO_2 etc. is known as—
(A) Green house effect
(B) Radioactive effect
(C) Ozone layer effect
(D) Solar effect

82. The 'Witches broom' of legumes is caused by a—
(A) Virus
(B) Mycoplasma
(C) Bacterium
(D) Fungus

83. Approximately one hundred diseases and pests are reported on—
(A) Wheat
(B) Gram
(C) Groundnut
(D) Rice

84. Sexual reproduction in *Spirogyra* involves fusion of—
(A) Two similar motile gametes
(B) Two similar non-motile gametes
(C) One motile and one non-motile gametes
(D) Two dissimilar motile gametes

85. The Indica varieties of rice is crossed with Japanese varieties as these are—
(A) High yielding
(B) Resistant to diseases
(C) Cheaper
(D) Short life-cycled annual

86. The nitrifying bacteria are—
(A) Autotrophic
(B) Saprophytic
(C) Parasitic
(D) Chemosynthetic

87. Foul smell in the water of tanks, ponds, etc., is due to—
(A) Anaerobiosis
(B) Aerobiosis
(C) Biological magnification
(D) Liralaction

88. Fruits, meats, milk, etc., are dried for preservation at room temperature by the process of—
(A) Dehydration
(B) Pasteurization
(C) Freeze
(D) Vernalisation

89. The stem of *Selaginella* is anatomically characterised by the presence of—
(A) Siphonostele
(B) Amphiploic
(C) Protostele
(D) Ectophloic siphonostele

90. The tropic level of lion in a forest ecosystem is—
(A) T_3 (B) T_4
(C) T_2 (D) T_1

91. Tropical dense forest is due to—
(A) High temperature and excess rain
(B) Low temperature and excess rain
(C) High temperature and lesser rain
(D) Wild animals (tigers, lions, bears etc.)

92. When plant cells are kept in hypertonic salt solution they get—
(A) Plasmolysed
(B) Deplasmolysed
(C) Turgid
(D) Flaccid

93. From which part of Atropa belladona the drug 'belladona' is obtained ?
(A) Leaves
(B) Roots
(C) Stems
(D) All the parts of the plant

94. The cotton thread fibres are—
(A) Fibres taken out from stem
(B) Epidermal hairs of seeds
(C) Epidermal hairs of fruits
(D) Fibres taken out from roots

95. Centrioles are found in—
(A) Chromosomes
(B) Spindle fibres
(C) Centrosomes
(D) Centromeres

96. The endoplasmic reticulum often bears—
(A) Lysosomes
(B) Centrioles
(C) Peroxisomes
(D) Ribosomes

97. Existence of coal and petroleum may be detected with the study of—
(A) Palaeobotany
(B) Ecology
(C) Bacteriology
(D) Economic Botany

98. Conversion of sugar into alcohol during fermentation is due to the direct action of—
(A) Temperature
(B) Micro-organisms
(C) Concentration of sugar solution
(D) Zymase

99. Which one of the following alternatives represents the gametophytic phase in Pinus ?
(A) Pinus plant
(B) Zygote
(C) Microspores and megaspores
(D) Male and female cones

100. Streptomycin is used to cure the diseases caused by the bacteria—
(A) Gram-positive
(B) Gram-negative
(C) Gram-neutral
(D) Both gram-positive and gram-negative

ANSWERS

1. (B) 2. (A) 3. (C) 4. (C) 5. (A)
6. (C) 7. (A) 8. (A) 9. (C) 10. (D)
11. (A) 12. (D) 13. (A) 14. (C) 15. (C)
16. (B) 17. (D) 18. (B) 19. (C) 20. (D)
21. (C) 22. (A) 23. (A) 24. (B) 25. (B)
26. (D) 27. (C) 28. (C) 29. (C) 30. (D)
31. (B) 32. (B) 33. (B) 34. (A) 35. (C)
36. (A) 37. (A) 38. (B) 39. (D) 40. (D)
41. (D) 42. (C) 43. (B) 44. (C) 45. (D)
46. (D) 47. (C) 48. (B) 49. (B) 50. (B)
51. (C) 52. (B) 53. (C) 54. (C) 55. (B)
56. (C) 57. (A) 58. (C) 59. (A) 60. (B)
61. (D) 62. (B) 63. (A) 64. (A) 65. (B)

66. (D) 67. (D) 68. (C) 69. (A) 70. (B)
71. (C) 72. (C) 73. (C) 74. (A) 75. (D)
76. (A) 77. (D) 78. (D) 79. (C) 80. (C)
81. (A) 82. (B) 83. (D) 84. (C) 85. (B)
86. (D) 87. (A) 88. (A) 89. (C) 90. (B)
91. (A) 92. (A) 93. (B) 94. (B) 95. (C)
96. (D) 97. (A) 98. (D) 99. (C)100. (D)

HINTS

2. The respiration that occurs only in light in green cells and responsible for release of extra CO_2 has been termed as photorespiration. Otto Warburg observed that the presence of excess O_2 in the atmosphere inhibits photosynthesis in green algae. Later on this inhibition was observed in several green plants. The inhibition was observed mostly in C_3-plants.

5. Maximum transpiration occurs in mesophytes because stomata are generally present on both surfaces of leaves and the guard cells show frequent movements. In most mesophytes stomata open during the day and close during night. As soon as light is available in the morning stomata start to open and after sometime open completely. Due to this complete opening the rate of transpiration increases.

6. Prokaryotes such as bacteria and cyanobacteria lack nuclear membrane.

12. The lysosomes are lytic in nature and are involved in the digestion of intracellular digestion. The function of lysosome membrane is to separate the hydrolytic enzymes from other part of the cell. Thus protecting the cell from self-digestion.

14. In somatic cells, cell cycle consists of four stages—G_1, S, G_2 and M phages. The first three phages G_1, S and G_2 are described in the interphase. During S-phage doubling of the chromosomes takes place which is accomplished by doubling of DNA and associated proteins in the chromosomes.

15. Bacterial cell wall is made up of polysaccharides, lipids and proteins. It contains a substance mucopeptide in which molecules of acetylglucosamine and acetylmuramic acid join each other. L-alanine, D-alanine, D-glutamic acid and diaminopimelic acid (DAP) are also found.

19. The division of nucleus is called karyokinesis whereas the division of cytoplasm is known as cytokinesis.

22. The thylakoids in the algal plastids are only of one kind and restricted to the stack itself. They are not closely packed or fused as in the granum of higher plants.

24. Since the gene is involved in the synthesis of protein and since protein represents in its primary structure linear combination of the 20 amino acids, the coded message of the gene must be in the form of words which determine the sequence of particular amino acids. If we make 3 letter words (*i.e.*, 3 adjacent nucleotides) then $4 \times 4 \times 4 = 64$ different types of three letter words (bases) will be possible.

35. **Bicollateral vascular bundles**—In this type of vascular bundle there are two patches of phloem one on each side of xylem and there are two strips of cambium one on each side of xylem. Thus, the arrangement is outer phloem, outer cambium, xylem, inner cambium and inner phloem.

37. **Phragmoplast**—A thin barrier which is formed across the equator in late cytokinesis develops into a cell plate during cell division in plant cells.

39. The liquid portion of vacuole, so-called vacuolar sap, is never a living substance.

40. The genes are responsible for growth and differentiation in an organism through regulation of protein synthesis which involves transcription and translation. The formation of *m*-RNA on DNA template is called transcription, while the process by which the linear sequence of nucleotides in a molecule of *m*-RNA directs the specific linear sequence of amino acids is called translation.

41. The male cone of *Pinus* is formed of microsporophylls (stamens) which are arranged spirally on a short axis forming a compact structure called male cone.

42. Nucleolus is a small, spherical body composed principally of ribosomal protein and located in the metabolic nucleus.

44. **Endosperm nucleus**—The triploid nucleus formed within the embryo sac of most seed plants by the fusion of two polar nuclei with one sperm nucleus.

47. Watson and Crick theory of DNA replication was tested by Meselson and Stahl in 1958. Using the isotopic and centrifugation techniques they confirmed the mechanism of DNA replication and called that type of replication as semi-conservative, because each of the two resultant daughter DNA molecules retains or conserves one parental polynucleotide strand.

48. Mitochondria contain numerous enzymes which take part in the oxidative steps of Kreb's cycle (or TCA cycle) in respiratory process. The high energy phosphate compound such as ADP and ATP are also synthesized and stored in mitochondria. These phosphate compounds after breakdown liberate tremendous amount of energy.

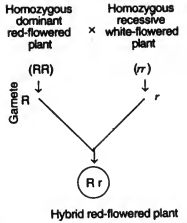
52. Pyramid of energy shows energy accumulation pattern at different trophic levels. Such a pyramid of all ecosystem is always upright. There is a gradual decrease in the energy content at successive trophic level from producers to consumers.

57. Two pairs of contrasting characters in pea pod were chosen by Mendel. These are—

(i) Pod colour → Dominant Yellow / Recessive Green

(ii) Shape → Smooth or Inflated / Constricted

58. Mendel crossed a homozygous dominant red-flowered plant with a homozygous recessive white-flowered plant. He obtained all red-flowered plants in first generation which were all hybrid.



Hybrid red-flowered plant

62. Plants growing on sandy-soil are referred to as psammophytes.

70. The bacterial ribosomes are of 70 s-type of ribosome which shows two sub-units whose sedimentation coefficient constants are 50 s and 30 s.

71. **Fossil fuel**—Any hydrocarbon deposit that may be used for fuel, such as petroleum, natural gas and coal.

81. The higher concentration of CO_2 may act as serious pollutant. Under normal conditions, the temperature at the surface of the earth is maintained by the energy balance of the sun rays that strike the planet and heat is radiated back into space. However, when there is an increase in CO_2 concentration, the thick layer of this gas prevents the heat from being re-radiated out this thick layer of CO_2 functions like the glass panels of a green house, allowing the sunlight to filter through but preventing the heat from being re-radiated in outer space. This is the so-called green house effect.

82. There has been growing evidence to suggest that some of the hopper transmitted diseases of the yellow and witches broom type, previously known to be caused by viruses, are actually caused by living organisms similar to mycoplasma.

84. The sexual reproduction in *Spirogyra* is called conjugation which involves the fusion of two morphologically identical but physiologically dissimilar gametes (one motile and one non-motile).

86. Nitrifying bacteria are the members of the family Nitrobacteraceae. Nitrifying bacteria convert nitrogen of ammonia into nitrite (NO_2), *e.g., Nitrosomonas* and convert nitrite compounds into nitrates, *e.g., Nitrobacter*. The synthesis of organic compounds from carbon dioxide by microorganisms using energy derived from chemical reactions is called chemosynthesis.

87. **Anaerobiosis**—A mode of life carried on in the absence of molecular oxygen, due to which foul smell in the water of tank and ponds is created.

88. As in absence of water all the metabolic activities of microbes get stopped.

89. The stem of *Selaginella* possesses a prosenchymatous cutinized epidermis, parenchymatous or sclerenchymatous cortex and a protostele of xylem, phloem and pericycle.

●●●

(Continued from Page 1742)

9. $F \cdot \Delta t = m(v + u)$

$\therefore \quad F = \dfrac{0{\cdot}15\,(20 + 12)}{0{\cdot}01}$

$= 480$ newton

11. Work $= F \cdot d \cos\theta$

$= 100 \times 10 \times \cos 60°$

$= 500$ joule

12. The work done by engine in 100 sec $= mgh$

$= 50 \times 10 \times 5$

$= 2500$ joule

Power $= \dfrac{\text{Work}}{\text{Time}} = \dfrac{2500}{100}$

$= 25$ watt

13. $E' = E + 3E = 4E$

$p = \sqrt{2mE}$

and $p' = \sqrt{2mE'}$

$= 2\sqrt{m \times 4E}$

$= 2\sqrt{2mE} = 2p$

$\dfrac{p' - p}{p} \times 100 = \dfrac{2p - p}{p} \times 100$

$= 100\%$

14. $\dfrac{1}{2}mv^2 = \dfrac{1}{2}kx^2$

$\Rightarrow \quad x = v\sqrt{\dfrac{m}{K}}$

15. The conservation of energy yields

$mgh = \dfrac{1}{2}kx^2$

$x = \sqrt{\dfrac{2mgh}{k}}$

$= \sqrt{\dfrac{2 \times 0{\cdot}04 \times 9{\cdot}8 \times 4{\cdot}9}{400}}$

$= \dfrac{98}{1000}\,\text{m} = 0{\cdot}098\,\text{m}$

$= 9{\cdot}8\,\text{cm}$

16. $W = \int F\,dx$

$= \int_0^{x_1} Cx\,dx = \dfrac{1}{2}Cx_1^2$

●●●

At a Glance

Parasitic Diseases

Cryptosporidium and Other Waterborne Pathogens

- *Causes of Emergence :* Protozoan-contaminated surface water; development near watershed areas; immunosuppression.
- *Mode of Transmission :* Fecalora, person-to-person.
- *Symptoms :* Diarrhea, vomiting, usually lasts less than 30 days.
- *Treatment / Prevention :* Fluid/electrolyte replacement.

Malaria

- *Causes of Emergence :* Migration and travel to mosquito-infested areas; urbanization; changing parasite biology; environmental changes; drug resistance.
- *Mode of Transmission :* Bite of infective Anopheles mosquito.
- *Symptoms :* Fever, headache, can cause respiratory and renal failure.
- *Treatment/Prevention :* Chloroquin but some forms may be resistant to most drugs.

BOTANY

1. The sequence of DNA bases determines the sequence of—
   (A) *m*-RNA
   (B) *t*-RNA
   (C) *r*-RNA
   (D) Amino acids
2. Which of the following RNAs carries a sequence of codons to the ribosomes ?
   (A) *m*-RNA
   (B) *t*-RNA
   (C) *r*-RNA
   (D) All of the above
3. Many ribosomes move along the *m*-RNA at a time. Collectively these are called as—
   (A) Polyribosome
   (B) Dictyosome
   (C) Centrosome
   (D) Lysosome
4. The central dogma of molecular biology says that—
   (A) The complementary sequence of nucleotides in *m*-RNA orders the correct sequence of amino acids of a polypeptide during transition
   (B) DNA is a template for its own replication and also for RNA formation during transcription
   (C) Both A and B
   (D) None of the above
5. When the anthers mature before the stigma, it is termed as—
   (A) Protogyny
   (B) Protandry
   (D) Dicliny
   (D) Heterostyly
6. In nature the tapetal cells are—
   (A) Haploid
   (B) Diploid
   (C) Triploid
   (D) Polyploid
7. The effect of pollen on the character of the seed-coat or pericarp is called—
   (A) Dicliny
   (B) Metaxania
   (C) Primordium
   (D) Allogamy
8. Frameshift mutations result when—
   (A) Base is deleted
   (B) Base is deleted or added
   (C) Base is added or deleted and the result is a nonfunctioning protein
   (D) None of the above
9. Which one of the following processes is referred to as translation ?
   (A) Decoding of the amino acids to proteins
   (B) Decoding of the triplet codons by *t*-RNA to *m*-RNA
   (C) Decoding of the triplet codons of *m*-RNA by *t*-RNA
   (D) None of the above
10. In glycolysis, from one hexose sugar, we obtain—
    (A) 2 Pyruvate molecules, 2 $NADH_2$ molecules and 2 ATP molecules
    (B) 2 ATP molecules only
    (C) 2 Pyruvate molecules and 2 ATP molecules
    (D) 2 Pyruvate molecules and 2 $NADH_2$ molecules
11. A gene mutation is an alteration in the nucleotide sequence of—
    (A) Ribosome
    (B) Dictyosomes
    (C) DNA polymerase
    (D) A Gene
12. Eutrophication in water results in reduction of—
    (A) Dissolved oxygen
    (B) Carbon dioxide
    (C) Nitrogen
    (D) Oxygen, Carbon dioxide and nitrogen
13. Which of the following is not a characteristic of photosystem-I ?
    (A) Molecular oxygen is not evolved in this system
    (B) It is located on inner surface of thylakoid
    (C) It is involved both in cyclic and non-cyclic photophosphorylation
    (D) It produces a strong reductant which reduces $NADP^+$ to $NADPH + H^+$
14. A plant which grows on another plant but does not depend for its food is termed as—
    (A) Epiphyte
    (B) Symbiosis
    (C) Saprophyte
    (D) Parasite
15. A bivalent tetrad is—
    (A) A duplicate chromosome composed of sister chromatids
    (B) The two daughter cells after meiosis-I
    (C) A homologous chromosome
    (D) The paired homologous chromosomes

ANSWERS WITH HINTS

1. (D) 2. (A) 3. (A) 4. (C) 5. (B)
6. (D) 7. (B) 8. (C) 9. (C) 10. (A)
11. (D) 12. (A) 13. (B) 14. (A) 15. (D)

1. DNA contains genetic information. The sequence of its bases determines the sequence of amino acids in a polypeptide.
2. Messenger RNA (*m*-RNA) carries a sequence of codons to the

(Continued on Page 1828)

Reasoning in Chemistry
(Why and How)

Q. 1. Lithium has the most negative standard potential of any element in the Periodic table, why ?

Reason—This is largely due to high hydration energy. The standard electrode potential E^0 and the standard Gibb's free energy change ΔG^0 are related as—

$$\Delta G^0 = -nFE^0$$

Where n is the number of electrons removed from the metal to produce ion and F is the Faraday constant.

The reaction, $Li^+ + e \rightarrow Li$, has the largest negative E^0 value (– 3·05 volts) and hence, the largest positive ΔG^0 value. Thus, the reaction does not occur. However, the reverse change ($Li \rightarrow Li^+ + e$) has large negative value of ΔG^0, so lithium liberates more energy than other metals when it reacts with water.

Q. 2. Potassium superoxide (KO_2) is used in the breathing masks, why ?

Reason—Potassium superoxide (KO_2) is used in space capsules, sub-marines and breathing masks, because it both produces dioxygen and removes carbon-dioxide. Both functions are important in life support systems.

$$4KO_2 + 2CO_2 \rightarrow 2K_2CO_3 + 3O_2$$

$$4KO_2 + 4CO_2 + 2H_2O \xrightarrow{\text{More } CO_2} 4KHCO_3 + 3O_2$$

Q. 3. $ZnCl_2$ and $CuCl_2$ solutions are acidified with HCl and H_2S gas is passed through them separately. Black CuS is precipitated but ZnS is not precipitated, why ?

Reason—In the aqueous solution H_2S dissociates as—

$$H_2S \rightleftharpoons 2H^+ + S^{2-}$$

On addition of HCl ($HCl \rightleftharpoons H^+ + Cl^-$) H^+ being common depresses the ionization of H_2S. Therefore, very low concentration of S^{2-} ions is there in the solution.

Since, CuS has very low solubility product (1×10^{-36}) so ionic product, $[Cu^{2+}]\ [S^{2-}]$ exceeds the solubility product of CuS and CuS is precipitated. The ionic product of $[Zn^{2+}]$ and $[S^{2-}]$ does not exceed the solubility product of ZnS and it does not precipitate. The solubility product of ZnS is high (1×10^{-23}).

Q. 4. Concentrated sulphuric acid is not used in the preparation of hydrogen by reaction with Zn, why ?

Reason—Zinc occupies higher position in the electrochemical series than hydrogen, so it can liberate hydrogen from H_2SO_4. Concentrated sulphuric acid is also an oxidising agent and zinc is a reducing agent and hence, redox reaction will take place. Zinc is oxidised and H_2SO_4 is reduced. Therefore, the following reaction takes place with conc. H_2SO_4.

$$Zn + \underset{\text{conc.}}{2H_2SO_4} \rightarrow ZnSO_4 + SO_2 + 2H_2O$$

Reaction with dil. H_2SO_4 is as—

$$Zn + \underset{\text{dil.}}{H_2SO_4} \rightarrow ZnSO_4 + H_2 \uparrow$$

Q. 5. Hydrogen peroxide is known as Merck's perhydrol, why ?

Reason—Hydrogen peroxide used for bleaching purpose is prepared by **Merck's process** in which calculated amount of sodium peroxide is added to 20% ice cold solution of H_2SO_4. A 30% solution of H_2O_2 corresponding to 100 volume strength thus, prepared is known as Merck's perhydrol.

Q. 6. Anhydrous magnesium chloride cannot be prepared by heating hydrated salt, why ?

Reason—When hexahydrate crystals of magnesium chloride ($MgCl_2 \cdot 6H_2O$) are heated to 200°C they undergo hydrolysis evolving steam and hydrochloric acid and yielding magnesium oxychloride, Mg_2OCl_2 which when heated to 600° C is converted into oxide.

$$2(MgCl_2 \cdot 6H_2O) \longrightarrow Mg_2OCl_2 + 2HCl + 11H_2O$$

$$2Mg_2OCl_2 + O_2 \longrightarrow 4MgO + 2Cl_2$$

Thus, anhydrous $MgCl_2$ cannot be prepared from hydrated salt by heating alone.

Q. 7. Chloroform is always stored in amber coloured bottles, why ?

Reason—Chloroform when exposed to sunlight, undergoes oxidation by oxygen of air to form poisonous carbonyl chloride ($COCl_2$) which is known as phosgene gas.

$$2CHCl_3 + O_2 \xrightarrow{\text{Light}} \underset{\text{Phosgene}}{2COCl_2} + 2HCl$$

For this reason chloroform is stored in amber coloured bottles which prevent light to come in the contact with the liquid. The bottles are also completely filled so that no air remains in the bottles.

Q. 8. Hydrogen is liberated at cathode and oxygen at anode on electrolysing aqueous solution of NaCl, why ?

Reason—The aqueous solution of NaCl ionizes as—

$$NaCl \rightleftharpoons Na^+ + Cl^-$$

$$H_2O \rightleftharpoons H^+ + OH^-$$

Na^+ and H^+ ions move towards cathode and Cl^- and OH^- towards anode. H occupies lower position in

electrochemical series than Na. Hence, H^+ will be discharged at cathode in preference to Na^+ ions.

$$2H^+ + 2e \rightarrow H_2 \uparrow \text{ At cathode}$$

Similarly OH^- ions will be discharged at anode in preference to Cl^- ions.

$$4OH^- - 4e \rightarrow 2H_2O + O_2 \uparrow \text{ at anode}$$

Q. 9. Nitrogen obtained from air has higher density than that of produced chemically from thermal decomposition of ammonium nitrite, why ?

Reason—Nitrogen separated from air is slightly heavier than that prepared from pure ammonium nitrite.

$$NH_4NO_2 \xrightarrow{\Delta} N_2 + 2H_2O$$

This is because nitrogen obtained from air contains some inert gases as impurities as they cannot be separated by any chemical method. Neon, argon, krypton and xenon are heavier than nitrogen. The presence of these heavier inert gases in nitrogen obtained from air makes the density higher than the nitrogen obtained chemically from pure ammonium nitrite.

Q. 10. Freons are very much more effective green house gases in atmosphere, though the amount of freons present is extremely small, why ?

Reason—In the upper atmosphere, freons undergo a **photolytic** reaction and produce free chlorine atoms (free radicals). These readily react with ozone. The ClO radicals formed decompose slowly, reforming chlorine radicals which react with more ozone. The chlorine radicals do not recombine to form Cl_2, because they need a three-body collision to dissipate energy and such collisions are extremely rare in upper atmosphere. There is no effective sink of chlorine radicals. Once formed they are used again and again, so a small number of radicals make a very effective **scavenger** for ozone.

$CFCl_3$, CF_2Cl_2, CF_3Cl $\xrightarrow{\text{Photolysis}}$ Cl

$Cl + O_3 \xrightarrow{\text{rapid}} O_2 + ClO$

$ClO \rightarrow Cl + O$

$ClO + O \rightarrow Cl + O_2$

Overall reaction—

$$2O_3 \longrightarrow 3O_2$$

Q. 11. Silicon tetrachloride is rapidly hydrolysed under ordinary conditions to give silicic acid. This reaction is used to prepare SiO_2 as thixotropic agent in paints and resins, how ?

Reason—$SiCl_4$ is commercially important. Large quantity of $SiCl_4$ is hydrolysed at high temperature in oxy-hydrogen flame giving very finely powdered SiO_2 rather than $Si(OH)_4$. This ultrafine SiO_2 is used as a thixotropic agent in polyster and epoxy paints and resins, and as an inert filter in silicon rubber.

$$SiCl_4 + 4H_2O \rightarrow Si(OH)_4 \xrightarrow{\Delta} SiO_2 + 2H_2O$$

Q. 12. Boric acid is a weak acid but it behaves as a strong acid in presence of glycerol, why ?

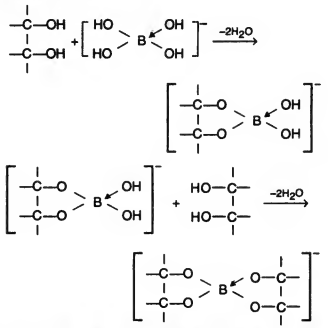
Reason—The boric acid (H_3BO_3) is very weak acid, it cannot be titrated against NaOH solution. If certain organic polyhydric compound such as glycerol is added, then H_3BO_3 behaves as a strong acid and can be easily titrated with NaOH.

$$H_3BO_3 + NaOH \rightarrow Na[B(OH)_4]$$

$$NaBO_2 + 2H_2O$$

Sod. metaborate

The cis-diol forms very stable complex with the $[B(OH)_4]^-$ and effectively removing it from the solution. Thus, reaction proceeds completely to the right. Thus, all H_3BO_3 reacts with NaOH: in effect it acts as a strong acid in presence of the cis-diol.



Q. 13. Solid carbon dioxide is known as dry ice, why ?

Reason—Solid carbon dioxide looks as transparent as ice. Since, it does not melt to give water, it remains dry, therefore, it is known as dry ice. It is called ice because it is used in producing very low temperature. It is a very good cooling agent. It produces the temperature as low as −100°C. For these reasons solid carbon dioxide is called dry ice.

Q. 14. Aralkylamines are stronger bases than arylamines, why ?

Reason—Aralkylamines ($ArCH_2NH_2$) are essentially aryl substituted alkylamines. The electron withdrawing inductive effect of the aryl group, no doubt makes the aralkylamines less basic than alkylamines but the intensity of this inductive effect is reduced due to greater distance separating the amino nitrogen from the aryl group. Therefore, aralkylamines, like alkylamines, should be stronger bases than arylamines.

$Ar \leftarrow CH_2 \rightarrow \ddot{N}H_2$	$Ar \leftarrow \ddot{N}H_2$	$R \rightarrow \ddot{N}H_2$
Aralkylamine	Arylamine	Alkylamine
4·60	9·38	3·37

●●●

Reasoning in Physics

Q. 1. What kind of spectrum is observed in solar radiation during total solar eclipse ?

Ans. At the time of total solar eclipse, there is no light from the central part (photosphere) of the sun on the earth. The light on earth comes from the chromosphere which contains various elements in the excited gaseous state. Now the spectrum consists of bright emission lines against a dark background. The bright line corresponds to the Fraunhofer lines observed in the normal solar spectrum.

Q. 2. The Fraunhofer lines from the atmosphere of hot stars are not fine and narrow but have an appreciable width, why ?

Ans. Due to high temperature, atoms of substances (in gaseous state) in the star are in rapid motion. Now due to Doppler's shift, the spectral lines (Fraunhofer lines) get broadened.

Q. 3. What is the use of flywheel in railway engine ?

Ans. A flywheel is a large heavy wheel with a long cylindrical axle passing through its centre and its centre of mass lying on its axis of rotation. It is constructed in such a way that most of its mass is concentrated at the rim of flywheel. This increases the moment of inertia about the axis of rotation. The function of moment of inertia is to oppose any change in uniform rotatory motion. Therefore when a wheel of large moment of inertia is coupled to an engine, it assures the running of engine smoother and steadier.

Q. 4. How a swimmer jumping from a height is able to increase the number of loops made in the air ?

Ans. The swimmer can increase the number of loops by pulling his legs and arms inward *i.e.*, by decreasing the moment of inertia. By doing so the angular velocity increases because the angular momentum remains constant.

Q. 5. What is metacentre ?

Ans. Metacentre is the point where the line of upthrust meets the centre line of the boat. For stable equilibrium, the metacentre must be higher than the centre of gravity. If a boat is loaded so that the metacentre is below the centre of gravity, then the equilibrium is unstable. Once the boat has started to roll, the upthrust and the weight form a couple which continues to roll the boat over.

Q. 6. In winter why do birds sit with their wings spread out ?

Ans. When the bird sits with wings spread out, the bird encloses a lot of air which is bad conductor of heat. The air does not allow the internal heat of the bird to escape outside and hence, protected from cold.

Q. 7. Thermal conductivity of air is less than that of felt but felt is a better heat insulator in comparison to air, why ?

Ans. The thermal conductivity of air is less than that of felt but open air transfers considerable heat by convection. So it can not act as a good heat insulator. There are fine holes in felt which contain air. This air is not free to move and hence convection currents can not be formed in it.

Q. 8. The diameter of the sun is of the order of 10^9 metre, still it appears to be a small disc, why ?

Ans. The distance of the sun from the earth is of the order of 10^{11} metre. It subtends an angle $\frac{10^9}{10^{11}}$ $\approx 10^{-2}$ radian (very small) at our eye. The same angle is subtended by a disc of 1 cm diameter placed at a distance of 1 metre from our eye. So the sun appears just like a small disc.

Q. 9. Why is a fluorescent light tube considered better than a tungsten filament type electric bulb ?

Ans. The efficiency of a filament lamp is only 2% to 3% and most of the part (98%) of the energy given to the lamp is wasted as heat. On the other hand, the efficiency of fluorescent tube is about 9%. So for the same amount of electrical energy, the fluorescent tube gives nearly 3 times more light than the filament lamp.

Q. 10. For what wavelength of light is our eye most sensitive ? What is the value in lumen/watt corresponding to this wavelength ?

Ans. Our eye is most sensitive to 5550 Å wavelength. Corresponding to this wavelength, the value of luminous flux/radiant flux = 685 lumen/ watt.

Q. 11. Why should circuits containing capacitor be handled cautiously even when there is no current ?

Ans. A charged capacitor, after removing the source of voltage, does not discharge itself. So it should be handled with precaution otherwise this may cause a severe shock to the handler.

Q. 12. A primary and a secondary cell have the same e.m.f. which of these will provide higher value of the maximum current that can be drawn ? Explain briefly.

Ans. The secondary cell will provide higher value of maximum current because its internal resistance is lower than primary cell.

Q. 13. Why does the glow of lamps become weaker when a heavy current appliance is switched on in the house ?

Ans. The connection of heavy current appliance decreases the total resistance of the system in the room as it is connected in parallel. Hence, current increases, thereby increasing the voltage drop across the lines and hence p.d. of line decreases.

Q. 14. What are the special characteristics of a heating wire and a fuse wire ?

Ans. The heating wire must have high resistance and high melting point

(Continued on Page 1835)

TRUE OR FALSE

Physics

1. Increasing the voltage across a coolidge X-ray tube increases the intensity of X-rays.

—T/F

2. Potentiometer is more suitable than voltmeter for measuring the e.m.f. of a cell.

—T/F

3. Faraday constant is the same for all elements.

—T/F

4. The lines joining places of equal declination are known as isoclinic lines.

—T/F

5. Cobalt steel is a suitable material for permanent magnets.

—T/F

6. The magnetic susceptibility of a paramagnetic substance is inversely proportional to its absolute temperature.

—T/F

7. A coil of metal wire is stationary in a non-uniform magnetic field. An e.m.f. is induced in the coil.

—T/F

8. The minimum energy (in eV) electrons must have for all the lines of all the series of hydrogen spectrum to appear when the hydrogen atoms are excited is 10·2 eV.

—T/F

9. A simple pendulum with a bob of mass m swings with an angular amplitude of 40°. When its angular displacement is 20°, the tension in the string is greater than mg cos 20°.

—T/F

10. A body can have energy without momentum.

—T/F

11. The binding energy of a satellite orbiting the earth is $-\frac{GM_e m}{2R}$.

—T/F

12. Bulk modulus of an incompressible liquid is zero.

—T/F

13. The average kinetic energy of gas molecules at 0°C is E. It will be 2E at 273°C.

—T/F

14. A black body is a good absorber of heat but it is a poor radiator.

—T/F

15. A closed organ pipe gives only even harmonics.

—T/F

Chemistry

16. The reaction between phenol and carbon tetrachloride in presence of aqueous alkali at 343°C yields the salicylaldehyde.

—T/F

17. An alkyl cyanide when reduced with $SnCl_2$ and hydrochloric acid, an aldimine is formed.

—T/F

18. Acyloins are produced when aliphatic carboxylic esters are treated with sodium in an inert solvent like ether followed by treatment with acid.

—T/F

19. In Bouveault-Blanc Reduction acids are reduced to aldehydes by sodium-alcohol as the reducing agent.

—T/F

20. The condensation between two molecules of benzaldehyde in presence of ethanoic solution of KCN gives a Keto-aldehyde.

—T/F

21. In the physisorption adsorbate is held on the surface of the adsorbent by van der Waal's forces.

—T/F

22. All organic compounds which form addition compounds with metals are known as organometallic compounds.

—T/F

23. A metal complex compound in which **Ligand** attached to metal atom can be readily replaced by other **ligands** is known as **labile complex**.

—T/F

24. Zinc, cadmium and mercury do not show characteristic properties of transition elements, though they belong to *d*-block elements.

—T/F

25. When 'n' is the number of unpaired electrons, in a metal ion, then the magnetic moment (μ) of metal ion is given by $\sqrt{2(n+2)}$ B. M.

—T/F

26. The atomic radii of Zr_{40} and Hf_{72} are 160 pm and 159 pm respectively. This similarity in atomic radii is due to the delayed effect of Lanthanide contraction.

—T/F

27. The several *f*-orbitals all have $l = 4$, meaning that there are four nodal surfaces slicing through the nucleus.

—T/F

28. Electronic configurations of Cr_{24} and Cu_{29} do not follow the $n + l$ rule.

—T/F

29. Increasing order of atomic weights of the following pair of elements is as—

$$Co < Ni, \quad Ar < K, \quad Te < I$$

—T/F

30. The atomic wt. of fluorine is 18·998 a.m.u. As the mass of ^{17}F nuclide is smaller than the average fluorine atom, ^{17}F must contain fewer neutrons. ^{17}F might be expected to decay by positron emission.

—T/F

Zoology

31. An inactive precursor of the engyme called a zymogen, is cleaved to form an active enzyme.

—T/F

32. The prostaglandins contain a five-membered ring of carbon atoms originally part of the chain of arachidonic acid.

—T/F

33. Cyclic electron flow produces ATP but not NADPH or O_2.

—T/F

34. Fishes originated from Amphibians in Devonian period.

—T/F

35. In reptiles Gular pouch is a sac present beneath the neck in both the sexes but is larger in males.

—T/F

36. Oxynctic cells are found in duodenum and secrete HCl.

—T/F

37. Diapedesis is a process during which RBCs cross the walls of blood capillaries and reach the injured part of the body.

—T/F

38. The afferent process of neuron is known as dendrite.

—T/F

39. Proteins are regulators of different activities in the body.

—T/F

40. Epiglottis is a cartilaginous lid like structure which acts as a valve of glottis and prevents entry of food or saliva in wind pipe or trachea.

—T/F

41. Glomerular filtrate is a fluid which is filtered from glomerulus into Bowman's capsule and contains useful as well as beneficial products.

—T/F

42. Centriole is the granular core of centrosome.

—T/F

43. Adrenal virillism is caused by excess secretion of sex corticoids in female.

—T/F

44. Titany is a disease caused by hyperparthyroidism.

—T/F

45. Male sex hormones are secreted by seminiferous tubules.

—T/F

Botany

46. In *Spirogyra*, the sexual reproduction involving conjugation and taking place between two nearest cells of the same filament is called lateral conjugation.

—T/F

47. A plant having two types of haploid structures in its life-cycle is termed as haplobiontic.

—T/F

48. Beadle and Tatum synthesized DNA and RNA in vitro.

—T/F

49. *Bacillus* species of bacteria causes anthrax disease of cattle.

—T/F

50. A nucleoside differs from a nucleotide in not having phosphate and sugar.

—T/F

51. The term genotype was proposed by de Vries and Kolreuter.

—T/F

52. Meiosis was first observed by Walter Flemming.

—T/F

53. Tunica-Corpus theory recognises only two zones in the apical meristems.

—T/F

54. The meristem present at the base of internode is intercalary.

—T/F

55. The presence of vessels and companion cells are characters of gymnosperms.

—T/F

56. The columella of moss is the sterile region of moss capsule.

—T/F

57. Both homologous chromosomes and alleles of each pair separate during meiosis.

—T/F

58. Maize grain is a fruit.

—T/F

59. Each spikelet bears a central stalk called rachilla.

—T/F

60. The gene which prevents the expression of another nonallelic gene is said to be epistatic.

—T/F

ANSWERS

1.	False	2.	True	3.	True	4.	False
5.	True	6.	True	7.	False	8.	False
9.	True	10.	True	11.	False	12.	False
13.	True	14.	False	15.	False	16.	False
17.	True	18.	True	19.	False	20.	False
21.	True	22.	False	23.	True	24.	True
25.	False	26.	True	27.	False	28.	True
29.	False	30.	True	31.	True	32.	True

33.	True	34.	False	35.	True	36.	False
37.	False	38.	False	39.	False	40.	True
41.	False	42.	True	43.	True	44.	True
45.	False	46.	True	47.	True	48.	False
49.	True	50.	False	51.	False	52.	False
53.	True	54.	True	55.	False	56.	True
57.	True	58.	True	59.	True	60.	True

HINTS

1. Increasing voltage across X-ray tube produces more energetic (hence more penetrating) X-rays. It has no effect on the intensity of X-rays which depends on the current flowing through the filament.

2. For measuring e.m.f. of a cell correctly, the cell should be in open circuit, *i.e.*, the measuring instrument should not draw any current from the cell. This condition is satisfied in measuring the e.m.f. by a potentiometer as no current is drawn from the cell, under measurement, at null point. But a voltmeter draws same current from the cell for its own deflection. Hence, it slightly lowers the e.m.f. which it is measuring. Moreover potentiometer is also more sensitive than a voltmeter.

3. Faraday constant is the quantity of charge required to liberate one gram equivalent of the substance. It is denoted by F and has a fixed value of 96500 C mol^{-1}. From Faraday's second law of electrolysis it follows that

$$F = \frac{E}{Z}$$

Where, E chemical equivalent and Z, the electrochemical equivalent of the element. Since E and Z are fixed for a substance, F also has a fixed value. Also

$$F = N \times e$$

where N is Avagadro's number.

4. The lines joining places of equal declination are isogonic lines and those joining places of equal dip are isoclinic lines.

5. Cobalt steel has high retentivity and high coercivity. Hence it acquires strong magnetism which is not wiped out by stray magnetic fields, mechanical ill-treatment and temperature changes.

6. This is the statement of Curie law $\chi \propto \frac{1}{T}$

7. Since the magnetic is not changing, e.m.f. will not be induced.

8. It is 13·6 eV, and not 10·2 eV.

9. $$T = mg\cos\theta + \frac{mv^2}{r}$$

$$T_{20} = mg\cos 20° + \frac{mv^2}{r}$$

$$T_{20} > mg\cos 20°$$

10. The body can have potential energy without momentum.

11. Binding energy is the energy given to a satellite in order that the satellite escape away from the gravitational field of the planet. Binding energy of a satellite is—

$$+\frac{GM_e \times m}{2R}$$

12. Bulk modulus

$$B = \frac{\text{Normal stress}}{\text{Volume strain}} = \frac{pV}{v}$$

For an incompressible liquid $v = 0$

$\therefore \quad B = \infty$

13. $$\frac{E_2}{E_1} = \frac{T_2}{T_1}$$

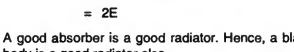
or, $$E_2 = E_1 \times \frac{T_2}{T_1}$$

$$= E \times \frac{273 + 273}{273 + 0}$$

$$= 2E$$

14. A good absorber is a good radiator. Hence, a black body is a good radiator also.

15. Closed organ pipe gives only odd harmonics.

16. 

Phenol — Salicylic acid

$+ 4NaCl + 2H_2O$

This reaction is known as Reimer-Tiemann reaction. When the reaction is carried out with chloroform under similar conditions, salicylaldehyde is formed.

17. $SnCl_2 + 2HCl \longrightarrow SnCl_4 + 2H$

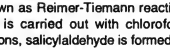
$R{-}C{\equiv}N + 2[H] \longrightarrow R{-}CH{=}NH$

Alkyl cyanide — Aldimine

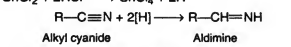
18. α-hydroxy ketones are known as acyloins.

$2CH_3COOC_2H_5 \xrightarrow{2Na,\ Ether}$

Ethyl acetate



Diketone



Acyloin

19. Bouveault-Blanc Reduction

$CH_3COOC_2H_5 \xrightarrow[2[H]]{Na,\ C_2H_5OH} C_2H_5OH + CH_3{\cdot}CH_2OH$

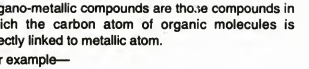
Ethylacetate — Alcohol

20. 

Benzaldehyde — Benzoin

22. Organo-metallic compounds are those compounds in which the carbon atom of organic molecules is directly linked to metallic atom.

For example—



are organo-metallic compounds.

C_2H_5O–Na is not an organo-metallic compound.

23. $[Ni(H_2O)_6]^{2+}$ is a labile complex because, the water molecules (ligand) can be replaced by ammonia (NH_3) molecules.

$$[Ni(H_2O)_6]^{2+} + 6NH_3 \longrightarrow [Ni(NH_3)_6]^{2+} + 6H_2O$$

24. As *d*-orbitals in all the three elements are saturated (d^{10}) and hence they do not show characteristic properties of transition elements.

25. If number of unpaired electron in an ion is '*n*', then

$$\mu = \sqrt{n(n+2)}\ \text{B.M.}$$

26. As atomic wt. increases in lanthanides, for every proton in the nucleus the extra electron goes to 4*f* orbitals. The 4*f* electrons constitute inner shell and are rather ineffective in screening the nuclear charge. Thus, there is gradual increase in effective nuclear charge experienced by outer electrons. Consequently, the attraction of the nucleus for electrons in the outermost shell increases as the atomic number increases and electron clouds shrinks. This results in gradual decrease in size of lanthanides with increase in atomic number.

Hf_{72} is immediately followed by lanthanides, therefore, its atomic size is nearly same as that of Zr_{40} which is just above Hf_{72} in the IV group.

28. In $n + l$ rule,

n = Principal quantum number

l = Azimuthal quantum number

Electron first enters that orbital which has lower value for $n + l$.

24th electron in Cr_{24} goes to $3d$ ($n + l = 3 + 2 = 5$) instead of $4s$ ($n + l = 4 + 0 = 4$)

29th electron in Cu_{29} goes to $3d$ instead of $4s$. Hence, $n + l$ rule is not followed by Cr_{24} and Cu_{29}.

29. Correct increasing order of atomic weights is as :

$$Ni < Co, \quad K < Ar, \quad I < Te$$

These are three anomalous pairs of elements in the periodic table.

30. ^{17}F is neutron poor, and it is relatively light nuclide, ^{17}F might be expected to decay by positron emission as—

$$_9F^{17} \longrightarrow {}_8O^{17} + {}_{+1}e^0 \quad (\beta^+\text{emission})$$

34. Fishes originated in Devonion period but not from amphibians. Inversely some amphibians are originated from stegocephalia.

36. Oxynctic cells are found in gastric epithelium and secrete HCl.

37. Diapedesis is a process during which WBCs cross the walls of blood capillaries and reach the injured part of the body.

38. The afferent process of neuron is known as axon.

39. Proteins are building block molecules in the body.

41. Glomerular filtrate is a fluid which is filtered from glomerulus into Bowman's capsule and contains useful as well as harmful products.

45. Male sex hormones are secreted by spermatogonia.

46. Ochoa and Kornberg synthesized DNA and RNA in vitro.

50. A nucleoside differs from nucleotide in not having phosphate. So, a nucleoside is a combination of nitrogenous base and sugar whereas nucleotide is a combination of nucleoside and phosphate.

51. The term 'genotype' was proposed by Johannson (1909) for hereditary or genetic constitution of an individual.

52. Meiosis was observed by Farmer and Moore.

53. Tunica-Corpus theory recognizes only two zones in the apical meristems. These are **tunica** and **corpus**. The tunica is one or more layered region at the apex. The corpus represents the central core with larger cells.

55. The presence of vessels and companion cells are characters of angiosperms.

57. According to chromosomal theory of inheritance, both homologous chromosomes and alleles of each pair separated during meiosis so that the gametes have one-half the total number.

●●●

FILL IN THE BLANKS

Physics

1. A liquid is being converted into its vapour at its boiling point. Specific heat of the liquid at this moment is.....
2. The difference in the gram molecular specific heats (C_p, C_v) of an ideal gas is nearly..... calorie/mol-K.
3. Unit of thermal resistance is.....
4. Equation of motion of a particle is $\alpha = -bx$ where α is acceleration, x is displacement from mean positon of rest and b is a constant. The time period of the motion is .....
5. Equation of S.H.M. is

   $$y = a \sin \omega t$$

   The maximum velocity of the particle undergoing this motion is.....
6. v_{rms} for a gas is proportional to the ..... of ..... temperature.
7. When a wire is stretched, elastic potential energy stored per unit volume of the wire is $\frac{1}{2} \times ..... \times .... .$
8. The dimension of velocity gradient is.....
9. The resistance of an ammeter reading upto 1 ampere is 0·81 Ω. To increase its range to 10 ampere, the resistance of the shunt required is ..... Ω.
10. In a dead beat galvanometer coil is wound on a light ..... frame.
11. A voltmeter has ..... resistance in ..... with its coil.
12. $_{11}Na^{24} \rightarrow {}_{12}Mg^{24} + ... + ...$
13. A γ-photon of energy 2·26 MeV produces electron-positron pair, the energy of each of these particles is..... MeV.
14. When a β-particle is ejected from the nucleus of $_{82}Pb^{210}$, the number of neutrons left in it is.....
15. The activity of a radioactive substance becomes $\frac{1}{16}$ of its initial value in 30 years. The half life of the substance is..... years.

Chemistry

16. Orbitals having equal energy are known as..... and those having unequal energy are called....
17. The wave nature of the electron is proved by ..... experiment.
18. The number of orbitals in a given energy level is given by ..... and the number of orbitals in a sub-level by.....
19. Certain crystals when heated, acquire electric charge on opposite faces. This property of crystals is known as.....
20. The alignment of magnetic moments in opposite direction resulting in net magnetic moment due to unequal number of parallel and antiparallel magnetic dipoles, is known as.....
21. The three dimensional orderly arrangement of constituent particle in a crystal is known as.....
22. For the rock salt structure the closest distance of approach between cation and anion is given by.....
23. In fluorite structure, the co-ordination number of cation is.....
24. The mass of a gas dissolved in per unit volume of a liquid at a particular temperature is directly proportional to the ..... of the gas above liquid at .....
25. A solution containing one mole of solute per 1000 g of solvent is known as..... solution. The molarity of a solution..... with the change in temperature.
26. Various resonating structures or contributing structures may differ only in ..... arrangement but should have ..... arrangement of .....
27. The systems having alternate single and double bonds are said to be..... systems.
28. Carbocation may be defined as a group of atoms that contains a carbon atom having..... charge and containing only..... electrons in its valence shell.
29. An atom or a group of atoms which contains an unpaired electron is called.....
30. Carbenes exist in two different forms, singlet and triplet. In singlet state unshared electrons are ..... whereas in triplet state they are .....

Zoology

31. In earthworm digestion and absorption occur in a long intestine whose dorsal surface is expanded by ..... that allows additional surface for absorption.
32. Leeches are able to keep blood flowing and prevent clotting by means of a substance in their saliva known as .....
33. In scorpion pincer-like chelicerae are.....
34. Mammals which have a cloaca and lay hard-shelled amniote eggs are.....
35. When an injury occurs, a capillary and several tissue cells are apt to rupture and to release .....
36. Change of skin colour in Amphibians with the environment is known as ..... .
37. The cavity of diencephalon is called .....

38. The production of sounds by some male insects, by rubbing together parts of body is called .....
39. Funnel like infundibular structure whose border is produced into a number of thickly ciliated finger like processes. This structure is called.....
40. Blood flowing in umblical cord of mammalian embryo is .....
41. Retina and lens of eyes in vertebrates are desired from embryonic.....
42. The ultimate source of organic variation is.....
43. In E. coli, "Lac" operon is induced by.....
44. In Haemophilic patients, blood clotting may take more time due to lack of ..... in blood plasma.
45. Complete removal of testis in men is called .....

Botany

46. In case the pith is sclerenchymatous it acts as .....
47. The first person to associate specific gene with a specific chromosome was .....
48. Sedimentation constant of ribosome is measured in .....
49. Genophore is DNA of .....
50. During interphase, proteins and RNA are synthesized in.....
51. Formation of ATP in photosynthesis is known as ....
52. Number of cotyledons in the embryo of sunflower is .....
53. Sex organs found beneath the notch in prothallus of a fern are .....
54. Palisade parenchyma is found in both sides of leaves of .....
55. Endodermoid is homologous to .....
56. Self-sterility is a contrivance for.....
57. Jack fruit is an example of.....
58. A transversely dehiscing capsule is called....
59. In embryosac, secondary nucleus is formed by the fusion of two .....
60. The fruit of cereal is described as.....

ANSWERS

1. Infinite
2. 2
3. $\frac{\text{second-°C}}{\text{kilocalorie}}$
4. $\frac{2\pi}{\sqrt{b}}$
5. $a\,\omega$
6. Square root, absolute
7. stress, strain
8. T^{-1}
9. 0·09
10. metallic
11. high, series
12. $-{}_1\beta^{\circ}, \bar{\upsilon}$
13. 0·62
14. 127
15. 7·5
16. Degenerate orbitals, nondegenerate orbitals.
17. Diffraction
18. n^2, $(2l+1)$
19. Pyroelectricity
20. Ferrimagnetism
21. Space lattice
22. $\frac{1}{2}$ Edge length or $\frac{a}{2}$
23. 8
24. Pressure, equilibrium
25. Molal, changes
26. Electronic, same, atoms
27. Conjugated
28. Positive, Six
29. Free radical
30. Paired, unpaired
31. Typhlosole
32. Hirudin
33. Feeding organs
34. Monotremes
35. Bradykinin
36. Metachrosis
37. Diocoel
38. Stridulation
39. Fimbriated funnel
40. 100% maternal
41. Ectoderm
42. Mutations
43. Lactose
44. Thromboplastin
45. Orchidectomy
46. Mechanical tissue
47. T. H. Morgan
48. Svedberg unit
49. Bacteria
50. G_1-phase
51. Photophosphorylation
52. Two
53. Archegonia
54. Monocots
55. Endodermis
56. Cross pollination
57. Composite fruit
58. Pyxidium
59. Polar nuclei
60. Caryopsis

HINTS

1. During vaporisation the temperature of the liquid remains constant *i.e.*, $\Delta T = 0$. Hence, the specific heat
$$c = \frac{Q}{m \times \Delta T} = \infty$$
2. $C_p - C_v = R$
$= 8{\cdot}31$ joule/mol-k
$= \frac{8{\cdot}31}{4{\cdot}18}$ cal/mol-k
$\simeq 2$ cal/mol-k
3. Thermal resistance
$$R = \frac{\theta_1 - \theta_2}{Q/t}$$
$$= \frac{t(\theta_1 - \theta_2)}{Q}$$
Where Q/t = H rate of flow of heat
unit $\rightarrow \frac{\text{second-°C}}{\text{kilocalorie}}$
4. Equation of simple harmonic motion is

$\alpha = -\omega^2 x$

where ω is angular velocity,

time period is given by

$$T = \frac{2\pi}{\omega}$$

In the present case

$\alpha = -bx$

$$\therefore T = \frac{2\pi}{\sqrt{b}}$$

5. $y = a \sin \omega t$

$$\therefore \quad u = \frac{dy}{dt}$$

$$= a\omega \cos \omega t$$

$$= a\omega\sqrt{1 - \sin^2 \omega t}$$

$$= a\omega\sqrt{1 - \frac{y^2}{a^2}}$$

$$= \omega\sqrt{a^2 - y^2}$$

$\therefore U_{max} = a\omega$

when $y = 0$

6. $$v_{rms} = \sqrt{\frac{3RT}{M}}$$

For a given gas

$$v_{rms} \propto \sqrt{T}$$

7. Suppose a wire of length L is stretched by a force F so that its length increases by *l*.

Work done

= average force × increase in length

$$= \frac{1}{2} F \times l$$

If the area of cross-section of wire is A, then the elastic potential energy stored in the wire is

$$U = \frac{1}{2} F \times l$$

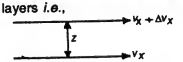
$$= \frac{1}{2} \frac{F}{A} \times \frac{l}{L} \times A L$$

$$= \frac{1}{2} \text{stress} \times \text{strain} \times \text{volume}$$

Hence elastic potential energy per unit volume

$$u = \frac{1}{2} \text{stress} \times \text{strain}.$$

8. Velocity gradient between two layers of the liquid is rate of change of velocity with perpendicular distance between the layers *i.e.*,

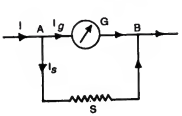


$$\text{Velocity gradient} = \frac{\Delta v_x}{\Delta Z}$$

$$= \left[\frac{LT^{-1}}{L}\right]$$

$$= [T^{-1}]$$

9.



$$I_g = I \cdot \frac{S}{S + G}$$

$$.1 = 10 \frac{S}{S + 0{\cdot}81}$$

$$\Rightarrow \quad S = \frac{0{\cdot}81}{9}$$

$$= 0{\cdot}09\ \Omega$$

10. When current is passed in the coil, the coil with its metallic frame moves in magnetic field. This motion induces eddy currents in the frame which oppose the motion of the frame Hence the pointer of the galvanometer soon gives steady deflection.

11. A voltmeter should have high resistance so that when it is connected in parallel to measure the potential difference across two points, it does not draw much current for its own deflection, thus the p. d. to be measured is not appreciably lowered.

12. $_{11}Na^{24} \rightarrow {}_{12}Mg^{24} + {}_{-1}\beta^0 + \bar{\upsilon}$

Mass number on both sides is the same (24). Atomic number has increased by 1. Hence a beta particle is ejected. Emission of β-particle is accompanied by the emission of an antineutrino ($\bar{\upsilon}$).

13. For electron-positron pair production minimum energy of γ-photon is 1·02 MeV. Extra energy will be equally divided in these two particles. Hence energy of each particle is

$$= \frac{1}{2}(2{\cdot}26 - 1{\cdot}02)$$

$$= 0{\cdot}62 \text{ MeV}$$

14. $_{82}Pb^{210} \xrightarrow{\beta} {}_{83}X^{210}$

$\therefore$ No. of neutrons

$$= 210 - 83 = 127$$

15. $$\frac{N}{N_0} = \left(\frac{1}{2}\right)^n$$

$$\frac{1}{16} = \left(\frac{1}{2}\right)^n$$

$$\Rightarrow \quad n = 4$$

$$\text{Half-life} = \frac{30}{4}$$

$$= 7{\cdot}5 \text{ year}$$

●●●

(Continued from Page 1781)

(B) X-chromosome
(C) Both A and B
(D) An autosome

10. Which of the following is a genetic trait in humans ?
(A) Albinism
(B) Leucoderma
(C) Tuberculosis
(D) Diphtheria

11. Number of autosomes in humans is—
(A) 22 (B) 44
(C) 23 (D) 46

12. Number of chromosomes in *Drosophila* is—
(A) Six (B) Eight
(C) Ten (D) Twelve

13. Homologous chromosomes similar in both sexes are called—
(A) Autosomes
(B) Androsomes
(C) Heterosomes
(D) None of the above

14. Genetic identity of a human male is determined by—
(A) Autosomes
(B) Nucleus
(C) Sex chromosomes
(D) None of the above

15. A haemophilic man marries a homozygous woman. What is the probability that their sons will be haemophilic ?
(A) 100% (B) 75%
(C) 50% (D) 0%

ANSWERS

1. (A) 2. (D) 3. (C) 4. (B) 5. (A)
6. (D) 7. (B) 8. (C) 9. (B) 10. (A)
11. (B) 12. (B) 13. (A) 14. (C) 15. (D)

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ASSERTION AND REASON TYPE QUESTIONS

In each of the following questions, a statement of assertion (A) is given and a corresponding statement of reason (R) is given just below it. Of the statements, mark the correct answer as—

(A) If both A and R are true and R is the correct explanation of A

(B) If both A and R are true but R is not the correct explanation of A

(C) If A is true but R is false

(D) If both A and R are false

(E) If A is false but R is true

PHYSICS

1. **Assertion (A) :** The phenomenon of pair production is not possible unless the energy of gamma ray photon is equal to or greater than 1·02 MeV.

   Reason (R) : The rest mass of an electron is 0·51 MeV.

   (A) (B) (C) (D) (E)

2. **Assertion (A) :** Positive rays are deflected by a magnetic field to a greater extent than cathode rays.

   Reason (R) : The positive ray particles are more massive than electrons.

   (A) (B) (C) (D) (E)

3. **Assertion (A) :** When light passes from one medium to another of different density the only quantity which is unchanged is its wavelength.

   Reason (R) : The wavelength is not related to the refractive index of the medium.

   (A) (B) (C) (D) (E)

4. **Assertion (A) :** A plane mirror forms a real image when a converging beam of light falls on it.

   Reason (R) : When a converging beam is reflected, the angle of reflection is not equal to the angle of incidence.

   (A) (B) (C) (D) (E)

5. **Assertion (A) :** Light incident normally on the first face of an equilateral glass prism ($\mu = 1{\cdot}5$) is certain to be totally internally reflected.

   Reason (R) : The critical angle for the given glass is less than 60°.

   (A) (B) (C) (D) (E)

CHEMISTRY

6. **Assertion (A) :** Hydrogen has three isotopes namely protium, deuterium and tritium.

   Reason (R) : All the three isotopes of hydrogen have same number of protons in their nuclei.

   (A) (B) (C) (D) (E)

7. **Assertion (A) :** The number of electrons in an neutral atom is always equal to atomic number of that atom.

   Reason (R) : The atomic number of the atom is equal to the number of protons in the nucleus of the atom.

   (A) (B) (C) (D) (E)

8. **Assertion (A) :** The radioactivity of Ra and Ra^{2+} is always same.

   Reason (R) : The radioactivity is an extra-nuclear phenomenon.

   (A) (B) (C) (D) (E)

9. **Assertion (A) :** $_{14}Si^{30}$, $_{15}P^{31}$ and $_{16}S^{32}$ are a group of isotones.

   Reason (R) : Isotones are atoms of different elements having different mass numbers and atomic numbers but same number of neutrons in their nuclei.

   (A) (B) (C) (D) (E)

10. **Assertion (A) :** Nuclear isomers are the atoms with same atomic number, same mass number but with different radioactivity.

    Reason (R) : Of the two nuclear isomeric nuclei one may be in the ground state whereas the other in the excited state.

    (A) (B) (C) (D) (E)

ZOOLOGY

11. **Assertion (A) :** Carbon dioxide is mainly transported in blood plasma as the bicarbonate ion.

    Reason (R) : The enzyme carbonic anhydrase found in red blood cells speeds the formation of the bicarbonate ion.

    (A) (B) (C) (D) (E)

12. **Assertion (A) :** The hormone aldosterone is secreted by the adrenal cortex after the low sodium ion (Na^+) content of the blood and the resultant low blood pressure causes the kidneys to release renin.

    Reason (R) : The presence of renin leads to the formation of angiotensin II, which causes the adrenal cortex to release aldosterone. Aldosterone causes the kidneys to retain Na^+, therefore, water is reabsorbed and blood pressure rises.

    (A) (B) (C) (D) (E)

13. **Assertion (A) :** Human inner ear contains the sense organs for balance. Movement of fluid past hair cells in the semicircular canals gives us a sense dynamic equilibrium.

    Reason (R) : Human inner ear contains calcium carbonate granules (otoliths) resting on hair cells. The movement of these granules gives us a sense of static equilibrium.

    (A) (B) (C) (D) (E)

14. **Assertion (A) :** When a sarcomere contracts, actin filaments slide past myosin filaments and the H zone all but disappears. Myosin has cross-bridges, which

attach to and pull actin filaments along.

Reason (R) : Whole skeletal muscles can only shorten when they contract; therefore, for a bone to be returned to its original position or the muscle to its original length, muscles must work in antagonistic pairs.

(A) (B) (C) (D) (E)

15. **Assertion (A)** : During the evolution of primates, various groups diverged in a particular sequence from the main line of decent.

Reason (R) : Prosimians (tarsiers and lemurs), which diverged first, are most distantly related to humans and most closely related to the original primates.

(A) (B) (C) (D) (E)

BOTANY

16. **Assertion (A)** : Prokaryotes reproduce asexually by cell division. The process is termed binary fission.

Reason (R) : Because this (binary fission) division produces two daughter cells that are identical to the original parent cell.

(A) (B) (C) (D) (E)

17. **Assertion (A)** : Binary fission (in unicellular prokaryotes) and mitosis (in unicellular eukaryotic protoctists and fungi) allow organisms to reproduce asexually.

Reason (R) : Mitosis in multicellular eukaryotes is primarily for the purpose of growth and repair of tissues.

(A) (B) (C) (D) (E)

18. **Assertion (A)** : A microtubule structure that brings about chromosomal movement during cell division is called kinetochore.

Reason (R) : A protein that cycles in quantity as the cell cycle progresses; combines with and activates the kinases that function to promote the events of the cycle.

(A) (B) (C) (D) (E)

19. **Assertion (A)** : The first set of reactions of photosynthesis takes place in the thylakoid, where chlorophyll and other pigments are located, is called light dependent reactions.

Reason (R) : Because they can not take place unless light is present.

(A) (B) (C) (D) (E)

20. **Assertion (A)** : The energy capturing portion of photosynthesis takes place in thylakoid membranes and can not proceed without solar energy.

Reason (R) : The synthesis portion of photosynthesis takes place in the stroma and does not directly require solar energy.

(A) (B) (C) (D) (E)

ANSWERS WITH HINTS

1. (A) 2. (E) 3. (D) 4. (C) 5. (A)
6. (B) 7. (A) 8. (C) 9. (A) 10. (A)
11. (A) 12. (A) 13. (A) 14. (B) 15. (B)
16. (A) 17. (B) 18. (E) 19. (A) 20. (B)

1. When an energetic γ-ray photon falls on a heavy substance, it is absorbed by some nucleus of the substance and an electron and a positron are produced. This is pair production.

$$h\upsilon = {}_1\beta^0 + {}_{-1}\beta^0$$

(γ-photon) (Positron) (Electron)

The rest mass energy of each of these particles is 0·51 MeV. Hence for pair production, it is essential that energy of γ-photon must at least be $2 \times 0{\cdot}51 = 1{\cdot}02$ MeV.

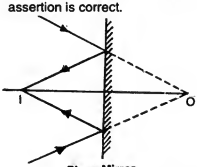
2. Electrons being much lighter than positive ray particles (ions) are deflected more in a magnetic field.

3. When light is refracted from one medium to another medium of different density, only frequency remains constant. Refractive index is related to wavelength as

$$\mu = \frac{v_a}{\lambda_m} = \frac{n\cdot\lambda_a}{n\cdot\lambda_g} = \frac{\lambda_a}{\lambda_g}$$

Thus assertion and reason both are wrong.

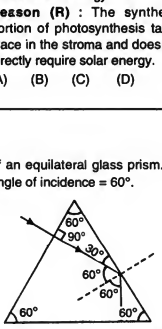
4. The formation of real image by a plane mirror when a convergent beam of light is incident on it is shown in the figure. Thus the assertion is correct.



Plane Mirror

The law of reflection that the angle of reflection is equal to angle of incidence holds even if incident light is convergent.

5. Figure shows the path of a normally incident ray on one face of an equilateral glass prism. Its angle of incidence = 60°.



The critical angle of glass-air interface is

$$\sin\theta = \frac{1}{\mu} = \frac{1}{1{\cdot}5}$$

$$\theta = 42°$$

Since the angle of incidence is greater than the critical angle, total internal reflection must take place.

18. A microtubule structure that brings about chromosomal movement during cell division is called spindle.

●●●

Do You Know?

Q. What is the advantage in choosing the wavelength of a light radiation as a standard of length ?

☞ Advantages are—

(1) Wavelength of a light radiation can be easily and accurately reproduced.

(2) It is not affected by environmental conditions such as temperature, pressure, etc.

(3) It is independent of other physical quantities.

Q. Why evaporation has a cooling effect ?

☞ When a liquid evaporates, molecules escape from its surface and move about freely as a gas. In a liquid, the vibrating molecules keep colliding with each other, some gaining kinetic energy and others losing it. At the surface, some of the faster, upward moving molecules have enough kinetic energy to overcome the attractions from other molecules and escape from the liquid. With these faster molecules gone, the average kinetic energy of those left behind is reduced *i.e.*, the temperature of the liquid falls. That is why evaporation has a cooling effect.

Q. How is the rate of evaporation increased ?

☞ The rate of evaporation (and, therefore, the rate at which the heat is lost from a liquid) is increased if—

(a) The surface area is increased (more of the faster molecules are near the surface)

(b) The temperature is increased (more of the molecules have enough kinetic energy to escape).

(c) The pressure is reduced (escaping molecules are less likely to rebound from other molecules back into the liquid).

(d) There is a draught across the surface (escaping molecules are removed before they can rebound).

(e) Gas is bubbled through the liquid.

Q. How does the thermal conduction take place in different media ?

☞ **In gases**—Faster moving molecules pass on kinetic energy to slower moving ones when they collide with them. In this way, heat is slowly conducted through gases.

In non-metal solids and liquids—The molecules are coupled to each other by the forces between them. So the molecules with most vibrational energy pass on some of this to those with less energy. However, this process of heat conduction is slow compared with that described next.

In metals—Metals contain free electrons which are in thermal equilibrium with the surrounding atoms. These electrons travel at high speeds and transfer energy quickly from one part of the metal to another. That is why metals are such good conductors of heat. They also conduct some heat by the transfer of vibrational energy.

Q. What are the *u*-values ?

☞ Heating engineers use *u*-values when calculating heat losses through walls, windows and roofs. A *u*-value is defined by the following equation—

Rate of flow of heat = *u*-value × area × temperature difference

Using the symbols in the panel on the left—

$$\frac{\Delta Q}{\Delta t} = u\text{-value} \times A\,\Delta T$$

For a material of thermal conductivity K and thickness x, the *u*-value = $\frac{K}{x}$. So, unlike K, the *u*-value depends on thickness. For good insulation, a low *u*-value is needed. The requirements for this are a low K and a high thickness. Here are some typical *u*-values—

***u*-values in $Wm^{-2}\,K^{-1}$**	
Single brick wall	3·6
Double brick wall with air space	1·7
Window, single glass layer	5·7
Double-glazed window	2·7

Q. What is the synthetic milk ?

☞ Synthetic milk minics real milk in all respects except taste and nutritional values. Its major ingredient is cheap cooking oil.

Synthetic milk is made by mixing refined oil, caustic soda, urea and detergents. A detergent is added to emulsify and dissolve the oil in water, giving the frothy solution, the characteristics of white colour of the milk.

The inflow of synthetic milk pumped into the market by unscrupulous traders, poses a grave risk for entire generation of infants, pregnant women, old people as well as heart and kidney patients.

Q. Allicin is an active component of Garlic.

☞ Raw garlic, it turns out, is an excellent, although smelly, natural broad-spectrum antimicrobial drug. Among other beneficial effects, it prevents cholesterol from clogging up the arteries.

The scientists have discovered that **allicin** has the power to render dysentery-causing amoeba harmless. It happens so because allicin blocks two groups of enzymes without which amoeba cannot survive or invade damaged tissues.

The researches provided evidences that allicin can act as an antioxidant, gobbling up harmful oxygen molecules believed to contribute to atherosclerosis, tumor growth, ageing and other processes.

Q. Lactose is an unique carbohydrate.

☞ It is also known as **'Milk sugar'**, which is the natural constituent of milk. The most commercial source of lactose is **cheese whey**, which is generated during the manufacture of cheese.

Lactose is mainly used in the pharmaceutical industry, as a filler/binder. The advantage of using lactose in the pharmaceutical formulations is its neutral taste, high compatibility with other drugs, optimum physical and chemical stability and availability in different physical and chemical forms for specific applications.

Lactose in capsules is mainly used as a carrier for the active compound, while it is used as a base material. There is no substitute for lactose in certain pharmaceutical products, such as antibiotics, vitamins and sustained drugs. Lactose is also credited with a role in minimising

cataract development and high blood pressure development.

Q. What is Human interferon ?

☞ For the first time, Isaacs and Lindenmann isolated the interferon in 1957. Interferon is defined as 'a protein which exerts virus non-specific antiviral activity, atleast in homelogous cells through cellular metabolic procedure involving the synthesis of both RNA and protein'. Thus interferon is secreted by human cells just to resist the immediate invasion by virus and multiplication of abnormal cells. In man there are three classes of interferon—

1. **Alpha interferon** (IFN–α) or leucocyte interferon.

2. **Beta interferon** (IFN–β) or fibroblast interferon.

3. **Gamma interferon** (IFN–γ) or immune interferon and lymphoblastoid interferon.

Interferon is used to cure many viral diseases such as common cold and hepatitis. It is species specific. In 1980, IFN–α and IFN-β were successfully produced from genetically engineered *E. coli* cells.

Q. What is clinical microbiology ?

☞ Clinical microbiology is the adaptation of microbiological techniques to the study of the etiological agents in infectious disease. Clinical microbiologists determine the nature of infectious disease and test the ability of various antibiotics to inhibit or kill the isolated microorganisms. A contemporary clinical microbiologist is also responsible for a wide range of microscopic and cultural studies in mycology, parasitology and virology. The consultative skill of the clinical microbiologist is sough by many physicians. The clinical microbiologist is often the most competent person available to determine the nature and extent of hospital-acquired infections, as well as public-health problems that affect both the hospital and the community.

Q. What is Ergotism ?

☞ Ergotism is a complex disease of humans and certain domestic animals caused by ingestion of grains and cereals infested with ergot (a fungus). There are three types of ergotism, *i.e.*, gangrenous, convulsive and hallucinogenic.

Gangrenous ergotism is generally characterized by lassitude, nausea and pains in limbs. Then alternating sensations of intense heat and cold occur. A bodily extremities become numb, livid watery vesicles may appear on the affected parts (usually arms and legs). Finally the diseased area turns black, dry and becomes mummified. In convulsive ergotism, various parts of the body become grossly deformed as a result of clonic or tonic convulsions or both. Generalized neurological stimulation causes epileptiform seizures, whereas specific stimulation might involve ravenous hunger and unusual breathing patterns. This form involves a longer recovery period and often results in permanent nerve damage and subsequent sensitization.

The hallucinogenic form often includes of one of the other types. In its more pure form, it is referred to as **choreomania**, St. Vitus's dance, or St. John's dance. Vivid hallucinations are accompanied by psychic intoxication reminiscent of the effects of many of the modern psychedelic drugs.

●●●

(Continued from Page 1807)

(A) Old man's beard
(B) Iceland moss
(C) Reindeer moss
(D) Both B and C

13. The lichen having deposition of selenium is—
(A) *Cetraria islandica*
(B) *Lobaria pulmonaria*
(C) *Parmelia molliuscula*
(D) *Evernia furfuracea*

14. Precisely, the upper cortex in heteromerous lichens is made up of—
(A) Parenchyma
(B) Prosenchyma
(C) Plectenchyma
(D) Prosoplectenchyma

15. 'Cyphellae' in lichens are analogous to which of the following structures of higher plants ?
(A) Stomata
(B) Mesophyll
(C) Palisade tissue
(D) Bundle sheath

16. Litmus is obtained from—
(A) Rocella montagnei
(B) Lasallia postulata
(C) Both A and B
(D) Cladonia crispata

ANSWERS

1. (B) 2. (B) 3. (C) 4. (C) 5. (D)
6. (B) 7. (A) 8. (B) 9. (D) 10. (C)
11. (A) 12. (D) 13. (C) 14. (D) 15. (A)
16. (C)

●●●

(Continued from Page 1814)

ribosomes, which are composed of *r*-RNA and proteins.

8. Frameshift mutations occur most often because one or more nucleotides are either inserted or deleted from DNA. The result of a frameshift mutation can be a completely nonfunctional protein because the sequence of codons is altered.

9. Translation (of protein synthesis) is the genetic information transfer from the nucleotide sequence of *m*-RNA to amino acid sequence of protein.

10. In glycolysis, each molecule of glucose (a hexose sugar) is broken down in stepwise biochemical reactions under enzymatic control into two molecules of pyruvic acid.

12. Due to addition of domestic waste, phosphates, nitrates etc. from wastes or their decomposition products in water bodies, they become rich in nutrients, especially phosphates and nitrate ions. Thus, with a passage of these nutrients through such organic wastes the water bodies become highly productive or eutrophic and the phenomenon as eutrophication. The algal blooms compete with their aquatic plants for light for photosynthesis. Thus, oxygen level is depleted.

13. Photosystem-I (PS-I) is located on the outer surface of the thylakoid.

●●●

General Mental Ability Test

Directions—(Q. 1–4) In each of the following questions, find out the one which is different from others.

1. (A) P O C G (B) K L I Z
   (C) B U D X (D) F Q M V
2. (A) $500 : 41\frac{2}{3}$ (B) $400 : 33\frac{1}{3}$
   (C) $100 : 8\frac{1}{3}$ (D) $300 : 24\frac{1}{3}$
3. (A) A E I M (B) B F J N
   (C) C G K O (D) D H L Q
4. (A) Counsel (B) Judge
   (C) Advocate (D) Lawyer

Directions—(Q. 5–6) In each of the following questions, find the required word/number from the alternatives.

5. Year : Month :: ? : ?
   (A) Success : Unsuccess
   (B) Rupee : Paisa
   (C) Adult : Child
   (D) School : Teacher
6. 144 : 10 :: 169 : ?
   (A) 12 (B) 11
   (C) 13 (D) 14
7. From the alternatives which one is the same as the given set ?
   Given set : (7, 56, 70)
   (A) 9 : 72 : 80 (B) 9 : 54 : 70
   (C) 8 : 72 : 88 (D) 8 : 64 : 78
8. Which one of the groups of letters will complete the given letter-series ?
   ab – aa – ca abc – – bca.
   (A) cbab (B) cbca
   (C) cbac (D) cbaa
9. Find out the wrong number in the given series.
   445, 221, 109, 46, 25, 11, 4.
   (A) 221 (B) 46
   (C) 11 (D) 109
10. Find out the pair of numbers that does not belong to the group due to lack of common property.
    (A) 38 : 50 (B) 18 : 27
    (C) 3 : 6 (D) 66 : 85
11. Find out the missing letter group in the given series.
    prt, ?, bdf, hjl, npr
    (A) vya (B) uwz
    (C) vxz (D) uxw
12. Arrange the following words in a meaningful order.
    1. Chair 2. Tree
    3. Wood 4. Seed
    5. Plant
    (A) 1, 3, 2, 4, 5
    (B) 4, 5, 3, 2, 1
    (C) 1, 2, 3, 4, 5
    (D) 4, 5, 2, 3, 1
13. *Rule* : "The third number in a set should be the sum and the fourth number should be the product of the first two numbers."
    Which one of the following sets follows this rule ?
    (A) (5, 10, 15, 20)
    (B) (3, 8, 11, 33)
    (C) (4, 6, 10, 24)
    (D) (2, 3, 6, 5)
14. If + means +, + means –, – means × and × means +, then
    48 + 16 + 4 – 2 × 8 = ?
    (A) 6 (B) 3
    (C) 112 (D) – 36
15. The following question has two clues and a target number series with a number missing. Use the clues and find the missing number.
    Clues : 9 (289) 8
    12 (361) 7
    Target : 8 (?) 14
    (A) 529 (B) 496
    (C) 484 (D) 441
16. If HUMIDITY as coded as UHMIIDTY, how is POLITICS coded ?
    (A) OPILITICS
    (B) OPLIITCS
    (C) OPLITISC
    (D) POILTISC
17. In a code message DOG is written as 433. How will CAT be written in that code ?
    (A) 314 (B) 431
    (C) 134 (D) 413
18. From the given alternative words, select the word which cannot be formed using the letters of the given word :
    ESTABLISHMENT
    (A) MENTAL
    (B) SHAME
    (C) ESTATE
    (D) ESSENCE
19. If BAT is coded as 528 and GLOVES as 379160 then BALL can be coded as—
    (A) 5277 (B) 2577
    (C) 5727 (D) 2757
20. The sum of the ages of a daughter and her mother is 56 years. After 4 years, the age of the mother will be 3 times that of the daughter. Their respective ages are—
    (A) 10 years and 46 years
    (B) 12 years and 44 years
    (C) 11 years and 45 years
    (D) 13 years and 43 years
21. From the given alternative words, select the one which can be formed using the letters of the given word—
    TRANSFORMATION
    (A) TRANSACTION
    (B) TRANSFER
    (C) INFORMANT
    (D) INFORMER
22. Which word in the responses cannot be formed by using the alphabets given in the blocks ?

BEAN	SEEM	DEAN
REEM		

    (A) REDEEM (B) DREAM
    (C) NEAR (D) BORE
23. A person starts from his house and walks 100 metres straight

towards south, takes a left turn and walks 75 metres straight towards east. How far is he from the starting point ?

(A) 175 metres
(B) 125 metres
(C) 100 metres
(D) 25 metres

24. 5 boys are sitting in a row. A is on the right of B. E is on the left of B but he is on the right of C. A is on the left of D. Who sits first from the left ?

(A) C
(B) D
(C) A
(D) B

ANSWERS

1. (D) 2. (D) 3. (D) 4. (B) 5. (B)
6. (B) 7. (D) 8. (D) 9. (B) 10. (A)
11. (C) 12. (D) 13. (C) 14. (B) 15. (C)
16. (B) 17. (A) 18. (D) 19. (A) 20. (B)
21. (C) 22. (D) 23. (B) 24. (A)

HINTS

1. In all the others there is one vowel.

2. In all the others, the first number is 12 times of the second.

3.

A	E	I	M	B	F	J	N	C	G	K	O	D	H	L	Q
	+4	+4	+4	+4	+4	+4	+4	+4	+4	+4	+4	+4	+4	+4	+5

4. All the others are synonyms of Vakil.

5. As 'Month' is a part of 'Year', similarly 'Paisa' is a part of a 'Rupee'.

6. As $\sqrt{144} \rightarrow 12 - 2 = 10$

Similarly $\sqrt{169} \rightarrow 13 - 2 = 11$

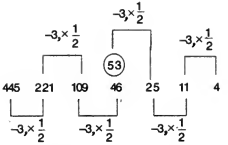
7. Given set = 7, 56, 70 (×8, +14)

$\therefore$ Required set = 8, 64, 78 (×8, +14)

8. The following series is formed :

a b c a, a b c a, a b c a, a b c a

9.



10. In all the others if first number is subtracted from the second an odd number is obtained.

11. p →(+6) V →(+6) u →(+6) h →(+6) n
r →(+6) x →(+6) d →(+6) j →(+6) p
t →(+6) z →(+6) f →(+6) l →(+6) r

14. By putting the proper signs in the given expression—

$48 + 16 + 4 - 2 \times 8$
$\Rightarrow 48 + 16 - 4 \times 2 + 8$
$\Rightarrow 3 - 8 + 8$
$\Rightarrow 3$

15. $(9 + 8)^2 = (17)^2 = 289$
and $(12 + 7)^2 = (19)^2 = 361$
$\therefore \quad ? = (8 + 14)^2 = (22)^2$
$= 484$

16. As,
HUMIDITY → UHMIIDTY
1 2 3 4 5 6 7 8 2 1 3 4 6 5 7 8
Similarly,
POLITICS → OPLI ITCS
1 2 3 4 5 6 7 8 2 1 3 4 6 5 7 8

17. The first letter of DOG is D which stands at 4th place in the alphabet. Hence in the code of DOG, first of all 4 is used. In the same way the first letter of CAT is C which stands at 3rd place in the alphabet. Hence, in the code of CAT, first of all 3 is used.

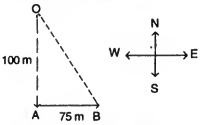
18. As the letter 'C' is not present in the given word **ESTABLISHMENT**, hence the word **ESSENCE** can not be formed.

19. BAT = 528,
and GLOVES = 379160
$\therefore$ B = 5, A = 2 and L = 7
(On comparing)
$\therefore$ BALL = 5277

20. Let the age of the daughter be x years.
$\therefore$ Age of her mother
$= (56 - x)$ years
$\therefore \quad 3 \times (x + 4) = (56 - x + 4)$
or, $\quad 3x + 12 = 56 - x + 4$
or, $\quad 3x + x = 56 + 4 - 12$
$\therefore \quad x = 12$
$\therefore$ Age of the daughter
$= 12$ years
and the age of the mother
$= 44$ years

22. The word 'BORE' cannot be formed because the letter 'O' is not present in any block.

23. The movement of the person is as shown below—



$OB = \sqrt{OA^2 + AB^2}$
$= \sqrt{(100)^2 + (75)^2}$
$= \sqrt{10000 + 5625}$
$= \sqrt{15625}$
$= 125$ m

24. The seating arrangement is as shown below :
C E B A D

●●●

GENERAL KNOWLEDGE

1. A child at the age of five normally has—
   (A) 16 teeth (B) 18 teeth
   (C) 20 teeth (D) 24 teeth
2. A plant cell is different from an animal cell by the presence of—
   (A) Nucleus
   (B) Cells membrane
   (C) Chloroplast
   (D) Cell wall
3. Which one of the following leaders was not associated with Swaraj Party ?
   (A) M. L. Nehru
   (B) C. R. Das
   (C) B. G. Tilak
   (D) None of these
4. In 1908 Bal Gangadhar Tilak was imprisoned and was sent to—
   (A) Singapore
   (B) Mandalay
   (C) Delhi
   (D) Andman and Nicobar
5. The Moderates decided to break with Extremists in—
   (A) 1906 (B) 1907
   (C) 1914 (D) 1919
6. The first session of Indian National Congress was held at—
   (A) Calcutta (B) Delhi
   (C) Bombay (D) Allahabad
7. Who said 'Better to reign in hell than to serve in heaven' ?
   (A) Shakespeare
   (B) Milton
   (C) Keats
   (D) Wordsworth
8. The minimum contribution to the government's tax revenue from among the following is made by—
   (A) Excise
   (B) Income-tax
   (C) Corporation-tax
   (D) None of these
9. In 'Asian Drama' Gunnar Myrdal discussed about—
   (A) Poverty in Asian countries
   (B) Modern Industries in Asian countries
   (C) The problem of military dictatorship in Asia
   (D) Neo-colonialism in Asian countries
10. 'Gresham's Law' in Economics is related to—
    (A) Supply and Demand
    (B) Circulation of currency
    (C) Consumption and supply
    (D) Distribution of goods and services
11. Regional Rural Banks started functioning in India, in—
    (A) 1971 (B) 1970
    (C) 1975 (D) 1973
12. The cause of inflation is—
    (A) Increase in money supply
    (B) Fall in production
    (C) Increase in money supply and fall in production
    (D) Decrease in money supply and fall in production
13. A case of dispute in the presidential election is referred to—
    (A) Election Commission
    (B) Supreme Court
    (C) Parliament
    (D) None of these
14. President of India is—
    (A) The head of government
    (B) The head of state
    (C) The head of state as well as government
    (D) None of these
15. Fundamental duties were introduced in the Constitution by—
    (A) 40th amendment
    (B) 42nd amendment
    (C) 43rd amendment
    (D) 44th amendment
16. Which one of the following fundamental rights has been deleted from our Constitution through constitutional amendment ?
    (A) Right against exploitation
    (B) Right to freedom of religion
    (C) Right to property
    (D) Right regarding freedom of speech and expression
17. As per our Constitution name of the Union is India or—
    (A) Hindustan
    (B) Bharat
    (C) Bharatvarsh
    (D) None of these
18. Which one of the following is not a feature of Indian Constitution ?
    (A) Federal Structure
    (B) Parliamentary Government
    (C) Presidential Government
    (D) Independence of Judiciary
19. The Constitution of India was adopted on—
    (A) November 26, 1949
    (B) January 26, 1950
    (C) January 26, 1949
    (D) January 26, 1948
20. National Defence College is situated at—
    (A) Khadakvasala
    (B) Dehradun
    (C) Wellington
    (D) New Delhi
21. Which city is known as city of seven hills ?
    (A) London (B) Rome
    (C) New York (D) Shimla
22. Nilgiris are part of the—
    (A) Eastern Ghats
    (B) Western Ghats
    (C) Vindhyachal
    (D) Tamil Nadu hills
23. What does the 17th Parallel separate ?
    (A) South and North America
    (B) North and South Korea
    (C) South and North Vietnam
    (D) South and North Yeman
24. Which of the following is the busiest of ocean trade routes ?
    (A) Suez Canal
    (B) Cape of Good Hope
    (C) North Atlantic
    (D) Panama Canal
25. 'White coal' is—
    (A) Uranium
    (B) Hydro-electricity
    (C) Ice
    (D) Diamond

26. Shimla is cooler than Amritsar although they are on the same latitude. This is because—
(A) Shimla is further North
(B) Shimla is at a greater height above sea level than Amritsar
(C) Shimla is further from equator
(D) Their longitudes differ

27. Climate of a place is dependent on several facts, which of them is the most significant ?
(A) Distance from sea
(B) Direction of wind
(C) Latitude
(D) Ocean currents

28. The most abundant constituents of earth's crust are—
(A) Igneous rocks
(B) Sedimentary rocks
(C) Metamorphic rocks
(D) Granite

29. The tropic of Cancer does not pass through—
(A) India (B) Egypt
(C) Mexico (D) Iran

30. In milk, fat content is reduced during—
(A) Winters
(B) Summers
(C) Rainy season
(D) No season

31. The maximum time gap between two successive sessions of parliament can be—
(A) 4 months
(B) 6 months
(C) 1 year
(D) As specified by the President

32. On which of the following date the constitution of Jammu-Kashmir came into force ?
(A) 26th January, 1957
(B) 26th October, 1947
(C) 31st October, 1951
(D) 27th October, 1950

33. Plants take nitrogen in the form of—
(A) Nitrate
(B) Nitrogen
(C) Nitrite
(D) Nitrogen oxide

34. Which one of the following books and authors is correctly matched ?
(A) Mitakshara–Vigyaneshwar
(B) Rajtarangini–Namdev
(C) Charu Chintamani–Someshwar
(D) Astadhyayi–Kalhana

35. Amir Khusro's name is associated with the invention of—
(A) Sitar (B) Sarod
(C) Tabla (D) Shehnai

36. 'Din-e-Ilahi' was accepted by—
(A) Raja Todarmal
(B) Tansen
(C) Birbal
(D) Raja Mansingh

37. Mahabharata was originally known as—
(A) Brihatkatha
(B) Kathasaritsagar
(C) Jayasamhita
(D) Rajtarangini

38. Who among the following presidents of India was elected unanimously ?
(A) Dr. Rajendra Prasad
(B) Dr. S. Radhakrishnan
(C) Neelam Sanjeev Reddy
(D) Dr. Shankar Dayal Sharma

39. Fundamental rights are enshrined in the constitution—
(A) Part I (B) Part II
(C) Part III (D) Part IV

40. Who is not appointed by the president ?
(A) Prime Minister
(B) Chief Justice of India
(C) Vice President
(D) Governor

41. Which of the following mountains are the oldest according to geological history ?
(A) Nilgiris
(B) Satpura Range
(C) Vindhyas
(D) Aravalli

42. The largest shore-line is along the state of—
(A) Gujarat
(B) Maharashtra
(C) Andhra Pradesh
(D) Kerala

43. Lakshdweep Island is situated in—
(A) Arabian sea
(B) Palk Strait
(C) Indian Ocean
(D) Bay of Bengal

44. The source of energy of sun is—
(A) Uranium fission
(B) Helium fission
(C) Hydrogen fission
(D) Hydrogen fusion

45. Which cells are destroyed by excessive drinking of alcohol ?
(A) Heart cells
(B) Liver cells
(C) Nerve cells
(D) Lung cells

46. Richter scale is used to measure—
(A) Earthquakes
(B) Ocean depth
(C) Intensity of wind
(D) Temperature of body

47. The slogan 'Inquilab Zindabad' was given by—
(A) Chandrasekhar Azad
(B) Mohd. Iqbal
(C) Bhagat Singh
(D) Subhash Chandra Bose

48. Which party was in power in U.K. when India became independent ?
(A) Labour
(B) Conservative
(C) Liberal
(D) There was National Government

49. Swaraj Party was founded by—
(A) Motilal Nehru
(B) Bal Gahgadhar Tilak
(C) C. Raj Gopalachari
(D) Sardar Balabhbhai Patel

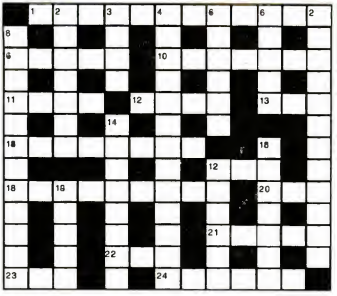
50. The first Europeans who started trade with Indians were—
(A) British (B) Danish
(C) Portuguese (D) Dutch

ANSWERS

1. (C) 2. (D) 3. (C) 4. (B) 5. (B)
6. (C) 7. (B) 8. (B) 9. (A) 10. (B)
11. (C) 12. (C) 13. (B) 14. (C) 15. (B)
16. (C) 17. (B) 18. (C) 19. (A) 20. (D)
21. (B) 22. (B) 23. (C) 24. (A) 25. (B)
26. (B) 27. (C) 28. (B) 29. (D) 30. (C)
31. (B) 32. (A) 33. (A) 34. (A) 35. (C)
36. (C) 37. (C) 38. (C) 39. (C) 40. (C)
41. (D) 42. (A) 43. (A) 44. (D) 45. (B)
46. (A) 47. (B) 48. (A) 49. (A) 50. (C)

●●●

CSV Crossword–6



Across :

1. The Mathematical tools devised by S. N. Bose and A. Einstein to handle a class of fundamental particles (12).
9. A thousandth part of a cubic metre (5).
10. Pertaining to the red planet (7).
11. Objects said to be sighted in the sky at random intervals but have not ever been identified ... (4).
12. The machine is not working, but it is ... (4).
13. Initials of the famous British Mathematician who patronised Ramanujam ... (3).
15. These on heating (after losing water) may become amorphous (8).
17. The plural of the female counterpart in the production of a zygote (3).
18. Something that is self evident (9).
20. This logic gate has the property of giving low output if any input is high ... (3).
21. An inert gas word derived from the meaning 'inert' itself (5).
22. A computer network may be covering a whole city (3).
23. These circuits generally arise while studying alternating currents (3).
24. The radius vector of a planet ..... equal areas in equal time (6).

Down :

2. The thermodynamic state variable which never decreases (7).
3. This data structure is very useful in computer softwares (4).
4. These are responsible for the famous 'Turn Paradox' (4, 9).
5. Inductances add-up in ..... (6).
6. Derived from 'ice', related to 'cake' (5).
7. These cyclotrons take the relativistic mass variation into account (12).
8. A detector of nuclear radiations (5, 7).
14. This explodes giving energy from mass ... (4, 4).
16. The energy difference between two energy bands (4, 3).
17. 1024 Hz is one ..... above 512 Hz (6).
19. The first name of the Academic guide of Newton (5).

Note—Its solution will be published in the next issue.

(Continued from Page 1736)

$$\frac{Q_1}{Q_2} = \frac{T_1}{T_2} = \frac{5}{4}$$

$$\Rightarrow \quad Q = \frac{4}{5} Q_1$$

$$Q_1 = \frac{4}{5} \times 10^4 \text{ J}$$

$$\therefore \quad W = Q_1 - Q_2 = 10^4 - \frac{4}{5} \times 10^4$$

$$= \frac{1}{5} \times 10^4 \text{ J} = 2 \times 10^3 \text{ J}$$

46. $$R = \rho \frac{l}{A}$$

$$= 3 \times 10^{-7} \times \frac{0{\cdot}01}{0{\cdot}01 \times 1}$$

$$= 3 \times 10^{-7}\ \Omega$$

48. $$B = \mu H$$

$$B = \left[\frac{0{\cdot}4}{H} + 12 \times 10^{-4}\right] H$$

$$1 = 0{\cdot}4 + 12 \times 10^{-4} H$$

$$H = \frac{1 - 0{\cdot}4}{12 \times 10^{-4}} = \frac{0{\cdot}6}{12 \times 10^{-4}}$$

$$= 500 \text{ A/m}$$

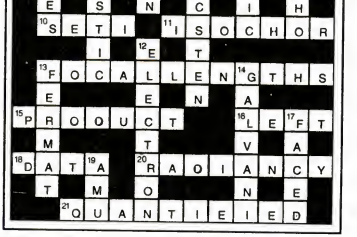
●●●

CSV Crossword–5

ANSWERS

Across : (1) ABERRATION (7) AREA (8) ION (9) MACH (10) SETI (11) ISOCHOR (13) FOCAL LENGTHS (15) PRODUCT (16) LEFT (18) DATA (20) RADIANCY (21) QUANTIFIED.

Down : (1) ACRES (2) ELASTIC (3) RAIN (4) TUNGSTEN (5) OHMIC (6) ECHO (12) ELECTRON (13) FERMAT (14) GALVANI (17) FACED (19) AMU



Correct Solution and Prize Winners of CSV Quiz No. 8

According to the rules of the CSV Quiz, all entry forms were examined. As a result, the following participants have qualified for various prizes. CSV sends them greetings and good wishes for their bright future. It also places on record its appreciation for their inquisitive nature and expresses obligation for their co-operation.

PRIZE WINNERS

First Prize

1. Pankaj Kumar Pathak
   Ashram Road Kamre
   AT. P.O. – Kamre
   Distt. Ranchi
   Bihar–835 222
2. Rajeev Bansal
   S/o Shri Raman Lal Agrawal
   B–26, Pratap Nagar (East)
   Maholi Road, Mathura
   U.P.–281 001
3. Vijay Kumar
   New Medicare
   L.B. Palace, Kadam kuan
   Patna, Bihar–800 003

CORRECT ANSWERS

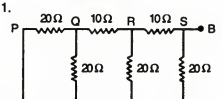
1. (A)	2. (C)	3. (B)	4. (D)	5. (*)
6. (C)	7. (D)	8. (C)	9. (C)	10. (*)
11. (B)	12. (B)	13. (D)	14. (C)	15. (B)
16. (B)	17. (D)	18. (A)	19. (D)	20. (D)

Note—(1) Questions 5 and 10 have not been included in the contest.

(2) Since the number of prize winners is quite large, the total amount of prize money has been equally distributed among the three first prize winners.

HINTS

1.



The point A can be shown as point A′ on right.

From left 20Ω and 20Ω (QQ′) in parallel = 10Ω

This 10Ω in series with 10Ω(QR) = 20Ω

This 20Ω and 20Ω (RR′) in parallel = 10Ω

This 10Ω in series with 10Ω (RS) = 20 Ω

This 20Ω and 20Ω (SS′) in parallel = 10Ω

Hence, the equivalent resistance between AB is 10Ω.

2. The successive equivalent circuits are shown in the figure (a) and (b).

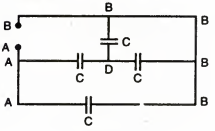


Fig. (a)

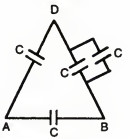


Fig. (b)

In figure (b) equivalent capacity between B and D is 2C as the condensers are in parallel.

This 2C and C in arm DA are in series. The equivalent capacity

$$= \frac{2C \times C}{2C + C}$$

$$= \frac{2C}{3}$$

Finally, this $\frac{2C}{3}$ and C in arm AB are in parallel.

Hence, the equivalent capacity between A and B

$$= \frac{2C}{3} + C = \frac{5C}{3}$$

3. Using Lami's theorem

$$\frac{F_1}{\sin\alpha} = \frac{F_2}{\sin\beta} = \frac{F_3}{\sin\gamma}$$

We have

$$\frac{T_1}{\sin 150°} = \frac{T_2}{\sin 120°} = \frac{10}{\sin 90°}$$

$$\therefore \quad T_1 = 10 \sin 150°$$

$$= 10 \sin(90° + 60°)$$

$$= 10 \cos 60°$$

$$= 10 \times \frac{1}{2} = 5N$$

Also, $T_2 = 10 \sin 120°$

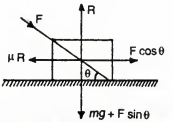
$$= 10 \sin (90° + 30°)$$

$$= 10 \cos 30°$$

$$= 10 \times \frac{\sqrt{3}}{2}$$

$$= 5\sqrt{3}\ N$$

4.



Resolving F in two components : along the surface (horizontal) F cos θ and perpendicular to the surface (vertical) F sin θ (downwards)

Since, there is no motion in vertical direction,

$mg + F \sin\theta = R$

Since, the motion in the horizontal direction is with constant velocity, there is no acceleration. Hence, net horizontal force is zero. Thus

$$F \cos\theta = \mu R$$

or, $F \cos\theta = \mu(mg + F \sin\theta)$

$F(\cos\theta - \mu \sin\theta)$

$= \mu\, mg$

Since, $\theta = 45°$, $\sin\theta = \cos\theta = \frac{1}{\sqrt{2}}$

$$\therefore \quad F\left(\frac{1}{\sqrt{2}} - \frac{0{\cdot}1}{\sqrt{2}}\right)$$

$$= 0{\cdot}1 \times 45 \times 10$$

$$\Rightarrow \quad F = \frac{\sqrt{2} \times 0{\cdot}1 \times 45 \times 10}{0{\cdot}9}$$

$$= 50\sqrt{2}\ \text{N.}$$

Work done by the man on the block

$$W = F \cos\theta \times d$$

$$= 50\sqrt{2} \cos 45° \times 10$$

$$= 50\sqrt{2} \times \frac{1}{\sqrt{2}} \times 10$$

$$= 500 \text{ Joule.}$$

5. For monoatomic gas

$$\frac{C_p}{C_v} = \gamma = \frac{5}{3}$$

$$\Rightarrow \quad C_p = \frac{5}{3} C_v$$

Also, $C_p - C_v = R$

or, $\frac{5}{3} C_v - C_v = R$

$$\Rightarrow \quad C_v = \frac{3}{2} R$$

$$\therefore \quad C_p = \frac{5}{3} \times \frac{3}{2} R$$

$$= \frac{5}{2} R$$

Similarly for diatomic gas

$$\frac{C_p}{C_v} = \gamma = \frac{7}{5}$$

$$\Rightarrow \quad C_p = \frac{7}{5} C_v$$

Also, $C_p - C_v = R$

$$\frac{7}{5} C_v - C_v = R$$

$$C_v = \frac{5}{2} R$$

$$\therefore \quad C_p = \frac{7}{5} \times \frac{5}{2} R$$

$$= \frac{7}{2} R$$

Hence, for mixture,

Average

$$C_p = \left(\frac{7}{2}R + \frac{5}{2}R\right) \times \frac{1}{2}$$

$$= 3R$$

and Average

$$C_v = \left(\frac{5}{2}R + \frac{3}{2}R\right) \times \frac{1}{2}$$

$$= 2R$$

$$\therefore \quad \gamma = \frac{3R}{2R}$$

$$= 1{\cdot}50$$

Note—This question is not being included in the contest as γ for a diatomic gas is $\frac{7}{5}$ not $\frac{7}{3}$ as given in the problem.

11. Allopatric speciation requires geographic isolation before reproductive isolation occurs. Sympatric speciation does not require geographic isolation for reproductive isolation to develop.
12. Genetic drift is particularly evident when a population is small.
13. The biological definition of a species recognizes that populations of the same species breed only among themselves and are reproductively isolated from other species.
14. In sexually reproducing diploid organisms, the heterozygote acts as a repository for recessive alleles whose frequency is low. In regard to sickel-cell disease, the heterozygote is more fit in areas with malaria and, therefore, the homozygotes are maintained in the population.
15. Adaptive radiation, as exemplified by the Galapagos finches, is a form of allopatric speciation. It occurs because the opportunity exists for new species to adapt to new habitats.
16. Tropisms are growth responses toward or away from unidirectional stimuli roots that bend toward the direction of gravity show positive gravitropism. Negative gravitropism of stems results in a bending away from the direction of gravity.
17. Phytochrome is a pigment that responds to both red and far-red light and is involved in flowering. Daylight causes phytochrome to exist as P_{fr}, but during the night it is converted to P_r by metabolic processes. P_{fr} form of phytochrome leads to activation of regulatory proteins that bind to genes.
18. Each ovule within the ovary contains a megasporocyte which divides meiotically to produce four haploid megaspores. The anthers contain microsporocytes, each of which divide meiotically to produce four haploid microspores.
19. In the carbon cycle, the reservoir is organic matter, calcium carbonate shells, and limestone. The exchange pool is the atmosphere : photosynthesis removes carbon dioxide, and respiration and combustion add carbon dioxide.
20. At resonance

$$\omega L = \frac{1}{\omega C}$$

$\therefore$ Impedance

$$Z = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}$$

$$= \sqrt{R^2} = R$$

●●●

(Continued from Page 1817)

while a fuse wire must have high resistance and low melting point.

Q. 15. Is Lenz's law a consequence of conservation of energy?

Ans. Yes, to produce a change in the magnetic flux work must be done and hence, the induced e.m.f. must oppose this if the energy of the system is to be conserved.

Q. 16. How can we identify whether the magnetic field at any point is due to the earth or due to some current carrying conductor ?

Ans. When a freely suspended small magnetic needle always stays in the direction of north-south, then the magnetic field is due to earth. But when the needle turns to some other direction and returns back to north-south direction after the current is switched off, then the magnetic field is due to current carrying conductor.

Q. 17. Is the magnetisation at saturation for a paramagnetic substance very much different from that for a saturated ferromagnetic substance of about the same size ?

Ans. Yes, the magnetisation at saturation for paramagnetic substance is very much smaller than saturation for a saturated ferromagnetic substance of about the same size.

Q. 18. Of the two identical galvanometers one is to be converted into an ammeter and the other into a milliammeter. Which of the shunts will be of larger resistance ?

Ans. The shunt of the milliammeter will be of larger resistance. The reason is that a large part of the main current will pass through galvanometer's coil which will work as a smaller range ammeter. ●●●

C S V QUIZ CONTEST

1. A highway motorist travels at a constant velocity of 45 $kmhr^{-1}$ in a 30 $kmhr^{-1}$ zone. A motor cyclist police officer has been watching him from behind a bill board and at the same moment, the speeding motorist passes the bill board, the police officer accelerates uniformly from rest to over take him. If the acceleration of the police officer is 10 $kmhr^{-2}$, how long does he take to reach the motorist ?
   (A) 7 hour
   (B) 8 hour
   (C) 9 hour
   (D) 10 hour

2. A 1 μF capacitor is charged to 100 volts and a 2 μF capacitor to 200 volts. They are then connected in parallel, positive plate to positive plate. What is the difference between initial and final energies ?
   (A) 0·0033 joule
   (B) 0·33 joule
   (C) 3·3 joule
   (D) None of these

3. A coil of inductance 0·50 H and resistance 100Ω is connected to 220 V, 50 Hz A.C. supply. What is the time lag between the voltage maximum and current maximum ? (tan 57·5° = 1·57)
   (A) 2·3 ms
   (B) 3·2 ms
   (C) 4·5 ms
   (D) 6·0 ms

4. A radio can tune over the frequency range of a portion of MW broadcast band (800 kHz to 1200 kHz). If its LC circuit has an effective inductance of 200 μH, what must be the range of its variable condenser ?
   (A) 80 pF to 250 pF
   (B) 88 pF to 300 pF
   (C) 40 pF to 198 pF
   (D) 88 pF to 198 pF

5. Eight rain drops of radius 1mm each falling down with a terminal velocity of 5 ms^{-1} coalesce to form a bigger drop. The terminal velocity of the bigger drop will be—
   (A) 0·05 cm s^{-1}
   (B) 2 cm s^{-1}
   (C) 20 cm s^{-1}
   (D) None of these

6. Which of the following compounds is used as a sequestering agent ?
   (A) Sulphuric acid
   (B) Microcosmic salt
   (C) EDTA
   (D) Corrosive sublimate

7. Which of the following categories of sustances are used in vacuum tubes to absorb gases, vapours and impurities ?
   (A) Getter alloys
   (B) Carbides
   (C) Chlorofloro carbons
   (D) Silicates

8. Which of the following is not a raw material for the preparation of synthetic milk ?
   (A) Refined oil
   (B) Caustic soda
   (C) Urea
   (D) Bleaching powder

9. Which of the following statements is not correct ?
   (A) Acetone is manufactured by cumene peroxidation process
   (B) When cracking of ethyl alcohol and steam is carried out at 40°C, acetone is obtained as a major product
   (C) Acetone is used for making protective coatings
   (D) Cumene peroxidation does not lead to formation of phenol

10. Which of the following compounds is used as disinfectant ?
    (A) BHC
    (B) DDT
    (C) Phenol
    (D) EDTA

11. Spongy bone—
    (A) Contains osteons
    (B) Contains red bone marrow where blood cells are formed
    (C) Lends no strength to bones
    (D) All the above are correct

12. When muscles contract—
    (A) Sarcomeres increase in size
    (B) Myosin slides past actin
    (C) The 'H' zone disappears
    (D) Calcium is taken up by calcium storage sacs

13. Which of the following are the first and last elements in a spinal reflex ?
    (A) Axon and dendrite
    (B) Sense organ and muscle effector
    (C) Ventral horn and dorsal horn
    (D) Motor neuron and sensory neuron

14. Excretion of a hypertonic urine in humans is associated with the—
    (A) Glomerular capsule
    (B) Proximal convoluted tubule
    (C) Loop of the nephron
    (D) Distal convoluted tubule

15. Which of the following animal breathes by positive pressure ?
    (A) Fish
    (B) Human
    (C) Bird
    (D) Frog

16. Regarding polarity of the spore in Filicophyta (Pteridophyta), it had proximal pole and distal pole. The hypothetical line connecting the two poles is called—
    (A) Tegillium
    (B) Polar axis
    (C) Equatorial axis
    (D) Endine

17. Which of the following shoots of *Pteridium aquilinum* bears leaves ?
    (A) Long shoots
    (B) Short shoots
    (C) Intermediate shoots
    (D) All of the above

18. Epilimnion is—
    (A) An enzyme

(B) A plant growth regulator having the same chemical formula as a gibberellin has

(C) The upper warmer oxygen rich circulating water layer region in a lake

(D) The plant having special type of anatomy called kranz type

19. Symbiotic association between protozoa and blue-green algae is called—

(A) Transitory cessation

(B) Coniconchia

(C) Grahamella

(D) Cyanelle

20. The antibiotics have no effect on viruses because—

(A) Viruses produce a thick covering and encyst themselves as endospores

(B) They kill all bacteria which act as host of virus

(C) Viruses show no metabolism of their own

(D) Viruses are too small in size for antibiotics to act upon

●●●

Rules for taking part in Quiz Contest of Competition Science Vision

1. All students or those appearing in competitive examinations can take part in this contest.
2. Candidates taking part in quiz contest will necessarily have to send their entries by a fixed date. Entries are to be sent by ordinary post. Please mark your envelope **'Quiz–Competition Science Vision'** on the top left hand side.
3. Answers given only on the form of the magazine will be admissible.
4. In the form there are four squares against each question number. Contestants should put a cross (×) in the square for the answer they think is correct. Giving more than one answer to a question will disqualify it.
5. Contestants should essentially write the number of questions they have solved.
6. Marks will be deducted for wrong answers.
7. The candidate sending the maximum number of correct answers will be given Rs. 400 as first prize. Next two candidates after that will get Rs. 300 and Rs. 200 as second and third prize respectively. If there are more than one candidate eligible for a prize, the amount will be equally distributed among them.
8. The decision of the editor will be final and binding in all cases, and will not be a matter for consideration of any court.

COMPETITION ADMISSION FORMAT

Solution to Quiz No. 11
Competition Science Vision
Last date for sending 28th February, 1999

Name Mr./Miss/Mrs. .....

Full Address .....

.....

.....

State .....Pin Code No. ☐☐☐☐☐☐

Age..... Academic Qualification.....

Competition examination for which preparing

.....

I have read and understood the rules of quiz contest of Competition Science Vision issued by Pratiyogita Darpan and agree to abide by them.

.....
(Signature)

RESULT

No. of questions attempted.....

No. of correct answers.....

No. of wrong answers.....

Marks obtained.....

ANSWER FORM

Q. No.	A	B	C	D	Q. No.	A	B	C	D
1.	☐	☐	☐	☐	11.	☐	☐	☐	☐
2.	☐	☐	☐	☐	12.	☐	☐	☐	☐
3.	☐	☐	☐	☐	13.	☐	☐	☐	☐
4.	☐	☐	☐	☐	14.	☐	☐	☐	☐
5.	☐	☐	☐	☐	15.	☐	☐	☐	☐
6.	☐	☐	☐	☐	16.	☐	☐	☐	☐
7.	☐	☐	☐	☐	17.	☐	☐	☐	☐
8.	☐	☐	☐	☐	18.	☐	☐	☐	☐
9.	☐	☐	☐	☐	19.	☐	☐	☐	☐
10.	☐	☐	☐	☐	20.	☐	☐	☐	☐

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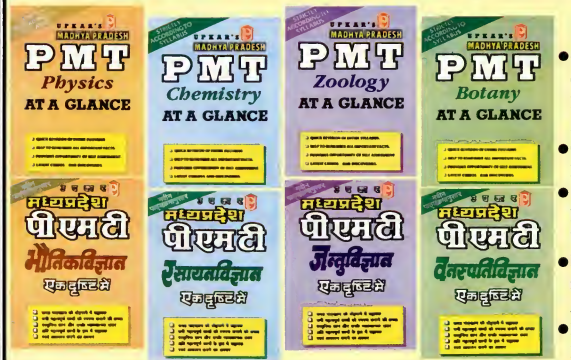

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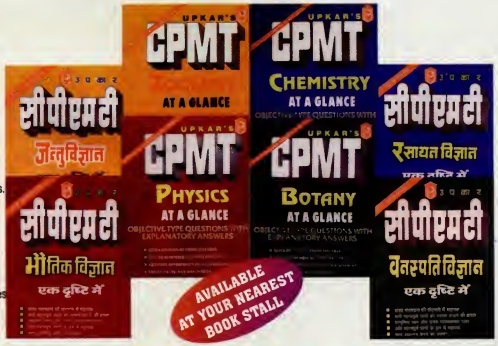

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